Causality, Emergence, Self-Organisation

Edited by

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Contents

Preface 5
Vladimir Arshinov and Christian Fuchs

I. Causality and Emergence

Emergence of Cause or Cause of Emergence? 19
Irina Dobronravova

An Integrative Image of Causality and Emergence 23
Klaus Brunner and Bert Klauninger

Decentralisation as Organising Principle of Emergent Urban Structures 36
Rainer E. Zimmermann

An Integrated Notion of "Law" 56
Annette Schlemm

The Spontaneity of Emergent Events and the Formation of Facts 76
Yuriy Myelkov

II. Principles of Synergetics

II.1. General Systems

Evolutionism, the Anthropic Principle, and New Rationality 85
Vyacheslav Stepin

A New Way of Thinking and A New World View.
On the Philosophy of Self-Organisation I. 131
Wolfgang Hofkirchner

Fundamental Properties of Self-Organisation 150
John Collier

Principles of Synergetics 167
Vladimir Budanov and Natalya Savicheva

Synergetic Knowledge: Between the Network and the Principles 182
Vladimir I. Arshinov and Vjacheslav E. Voitsekhovich

II.2. Physical Systems

Dialectical Philosophy and Self-Organisation 195
Christian Fuchs

Emergence and Self-Organisation of Complex Systems.
The Role of Energy Flows and Information 245
Norbert Fenzl

Spinoza, the "Very Untranscendental". Ernst Bloch´s Interpretation of Spinoza 259
Doris Zeilinger

II.3. Biological Systems

Organisation in Biological Systems 287
John Collier

II.4. Social Systems

The Autocreation of Communication and the Re-creation of Actions in Social Systems 303
Christian Fuchs and Gottfried Stockinger

Action, Communication, and Creativity.
A Contribution from a Meadean Perspective 322
Franz Ofner

Preface

This book is a result of the international INTAS research project "Human Strategies in Complexity. Philosophical Foundations for a Theory of Evolutionary Systems" (see http://www.self-organization.org) that has been funded by the International Association for the Promotion of Cooperation with Scientists from the New Independent States of the Former Soviet Union (INTAS) of the European Union (contract number MP/CA 2000-298) and supported by the Austrian Ministry for Education, Science, and Culture. The project is a co-operation between research teams from Russia, Ukraine, Germany, and Austria. The project team includes partners from the Synergetics Group at the Institute of Philosophy at the Russian Academy of Sciences, the Chair of Philosophy and Methodology of Science at the Kiev National Shevchenko University, the Interdisciplinary Study Group on Philosophical Problems of Foundation at the University of Kassel, and the Unified Theory of Information Group at the Institute of Design and Technology Assesment at the Vienna University of Technology.

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Emergence and self-organisation are the two main concepts that this book and the research project "Human Strategies in Complexity" focus on. We want to give a general characterisation of both concepts.

Aspects of emergence are:

- *Synergism:* Emergence is due to the productive interaction between entities. Synergy is a very general concept that refers "to combined or ´co-operative´ effects – literally, the effects produced by things that ´operate together´ (parts, elements or individuals)" (Corning 1998: 136). Synergy takes place and shapes systems on all organisational levels of matter, it is a fundamental quality of matter. Synergies between interacting entities are the cause of the evolution and persistence of emergent systems.

- *Novelty:* On a systemic level different from the level of the synergetically interacting entities new qualities show up. Emergent qualities are qualities that have not been previously observed and have not previously existed in a complex system ("a whole is more than the sum of its parts").
- *Irreducebility*: The new produced qualities are not reduceable to or derivable from the level of the producing, interacting entities.
- *Unpredictability*: The form of the emergent result and the point of emergence can´t be fully predicted.
- *Coherence/Correlation*: Complex systems with emergent qualities have some coherent behaviour for a certain period of time (Goldstein 1999). This coherence spans and correlates the level of the producing entities into a unity on the level of emergence (ibid.).
- *Historicity:* Emergent qualities are not pre-given, but the result of the dynamical development of complex systems.

Emergence is a fundamental quality of self-organising systems. Aspects of self-organisation are:

- *Systemness:* Self-organisation takes place in a system, i.e. in coherent whole that has parts, interactions, structural relationships, behaviour, state, and a border that delimits it from its environment.
- *Complexity:* Self-organising systems are complex systems. The term "complexity" has three levels of meaning: 1. there is self-organization and emergence in complex systems (Edmonds 1999), 2. complex systems are not organised centrally, but in a distributed manner; there are many connections between the system´s parts (Kauffman 1993, Edmonds 1999), 3. it is difficult to model complex systems and to predict their behaviour even if one knows to a large extent the parts of such systems and the connections between the parts (Heylighen 1996, 1997; Edmonds 1999). The complexity of a system depends on the number of its elements and connections between the elements (the system´s structure). According to this assumption, Kauffman (1993) defines complexity as the "number of conflicting constraints" in a system, Heylighen (1996) says that complexity can be characterised by a lack of symmetry (symmetry breaking) which means that "no part or aspect of a complex entity can provide sufficient information to actually or statistically predict the properties of the others parts" and Edmonds (1996) defines complexity as "that property of a language expression which makes it difficult to formulate its overall behaviour, even when given almost complete information about its atomic components and their inter-relations". Aspects of complexity are things, people, number of elements, number of relations, non-linearity, broken symmetry, non-holonic constraints, hierarchy and emergence (Flood/Carson 1993).

- *Cohesion:* Cohesion means the closure of the causal relations among the dynamical parts of a dynamical particular that determine its resistance to external and internal fluctuations that might disrupt its integrity (Collier 2003, 2004). It is a "dividing glue" of dynamic entities (ibid.).
- *Openness*: self-organisation can only take place if the system imports energy which is transformed within the system, as a result energy is exported. Self-organisation is entropy reduction.
- *Bottom-up-Emergence:* A perturbation causes the system´s parts to interact synergetically in such a way that at least one new quality on a higher level emerges.
- *Downward Causation:* Once new qualities of a system have emerged they along with the other structural macor-aspects of the system influence, i.e. enable and constrain, the behaviour of the system´s parts. This process can be described as top-down-emergence if new qualities of certain parts (seen as wholes or systems themselves) show up.
- *Non-linearity*: Emergence is based on non-linear causality, i.e. causes and effects can´t be mapped linearly: similar causes can have different effects and different causes similar effects; small changes of causes can have large effects whereas large changes can also only result in small effects (but nonetheless it can also be the case that small causes have small effects and large causes large effects).
- *Feedback loops, Circular causality*: there are feedback loops within a self-organising system; circular causality involves a number of processes p_1, p_2, …., p_n ($n \geq 1$) and p_1 results in p_2, p_2 in p_3, …. , p_{n-1} in p_n and p_n in p_1. Self-organisation can be envisioned as a circular loop in the sense that the level of elements and the structural level are complexly mutually causally related. This mutual relationship is productive, complex, and non-linear.
- *Information:* All self-organising systems are information generating systems. Information is the processual relationship between self-organising material units that form a coherent whole that has emergent properties.
- *Relative Chance*: there are both aspects of chance and necessity in self-organising systems; certain aspects are determined, whereas others are relatively open and according to chance
- *Hierarchy: The s*elf-organisation of complex systems produces a hierarchy in two distinctive senses: 1. The level of emergence is a hierarchically higher level, i.e. it has additional, new emergent qualities that can´t be found on the lower level which is comprised by the components. The upper level is a sublation of the lower level. 2. Self-organisation results in an evolutionary hierarchy of different system types, these types are hierarchically ordered in the sense that upper levels are more complex and have additional emergent qualities.

- *Globalisation and Localisation:* Bottom-up-emergence means the globalising sublation of local entities, downward causation the localisation of more global qualities.
- *Unity in Plurality (Generality and Specifity)*: On the one hand each type of self-organising system is characterised by a number of distinctive qualities that distinguish it from other self-organising systems. On the other hand each type of self-organising system also shares general principles and qualities with all other types of self-organising systems. Both generality/unity and specifity/plurality are characteristic of self-organising systems.

Science itself is a self-organising system. It develops in such a way that phases of relative stability are followed by phases of fundamental innovations. The latter constitute discontinuous breaks that are characterised by rapid change and fluctuations from which new scientific order emerges. During such scientific bifurcation points a new scientific paradigm emerges. Such a paradigm refers to the "entire constellation of beliefs, values, techniques, and so on shared by the members of a given community" (Kuhn 1962: 175). The evolution of science is a discontinuous process where the emergence of new paradigm causes spontaneous rupture and new development stages. Such paradigm shifts can be both found in particular scientific disciplines as well as in science as a general system.

Since the sixties a scientific paradigm shift has been underway towards a Theory of Evolutionary Systems. During the last two decades an increasing body of scientific literature on topics of self-organisation has emerged that taken together represents a huge shift of focus in science:

- from structures and states to processes and functions
- from self-correcting to self-organising systems
- from hierarchical steering to participation
- from conditions of equilibrium to dynamic balances of non equilibrium
- from single trajectories to bundles of trajectories
- from linear causality to circular causality
- from predictability to relative chance
- from order and stability to instability, chaos and dynamics
- from certainty and determination to a larger degree of risk, ambiguity and uncertainty
- from reductionism to emergentism
- from being to becoming

Still there are gaps in theoretical knowledge about self-organisation to which philosophical theorizing may put forward heuristic offers. The project "Human

Strategies in Complexity" undertakes the task to help to fill some of the gaps. The objectives are:

- To contribute to a single and comprehensive transdisciplinary scientific research programme for investigating self-organisation by elaborating selected epistemological, ontological and axiological implications, thus attempting at unifying the scattered approaches in the so-called non-linear science of complexity.
- To contribute to a scientific understanding of the "feedback-loop" of human action and reflection in a historical moment in which the destiny of the world system is at stake.

In July 1999 a first official meeting of the project members took place in Vienna that was intended to exchange scientific views on self-organisation and draft a joint research proposal. As a result a first project proposal was produced that was submitted to the INTAS-program. After one redraft it was accepted in early 2001 and achieved excellent marks in the evaluation process. It had ranking two in the evaluation procedure, there were 19 projects out of 90 funded in the fields of economics, human and social sciences. Thus, the success rate was less than 20 %. The project started in July 2001, its duration is 36 months.

The papers gathered in this volume are the outcome of a project seminar week that took place in Yalta from July 1st until 8th, 2002. The contributions were written for the subtasks 1.1. and 1.2. of the project. These two tasks concentrate on the issues "Causality and Emergence" (1.1.) and "Principles of Synergetics" (1.2.). The two sections of this book have been named according to the tasks, the structure of this volume reflects the structure of the project.

The objective of the subtask on "Causality and Emergence" was to determine the place of emergence within the framework of causality in the initial phase of the genesis of evolutionary systems (formation, becoming) and in other phases of their development as well as in their hierarchical structure (being), using the differentiation of macro- and micro-causality, against the background of the chasm between determinism and indeterminism. The results gathered in part one this book clarify the relationship of causality and emergence in self-organising systems.

The objective of the subtask on "Principles of Synergetics" was to following the line of recent results given by several researchers in self-organisation theory, extract a bundle of elementary principles which can serve as a general scientific approach to understanding evolutionary systems and which can help to clarify the concrete conditions which are responsible for the co-evolution of the worldly and its cognitive representation and comprehending. The results gathered in part two of this book outline both general and specific principles of self-organisation.

We want to point out the results of these two subtasks shortly by summarising the main arguments of the contributions.

Part 1: Causality and Emergence

Irina Dobronravova ("Emergence of Cause or Cause of Emergence?") argues that in a non-linear system chance and necessity are interconnected. Although a choice in a bifurcation point would be a choice by chance, it would be a choice between two certain possibilities (there is a set of a few certain possibilities for the critical point in general). These possibilities would be defined by attractors of the non-linear medium. The emergence of a set of possibilities and the selection of one possibility in a bifurcation point would be signs of integrity of the medium of self-organisation. Integrity and the presence of alternatives would not exclude, but pre-suggest each other. The meaning of integrity, characterised by the presence of the parameter of order, would be preserved during all phases of the self-organisation processes. She considers a bifurcation point as a point of the formation of causes. In such a point the system would make a random choice between two equally probable solutions. The fluctuation would select one of the two possibilities and it could be understood as the cause whose action is the formation of a coherent structure, i.e. the choice by the system of a certain evolutionary pathway. Hence the situation, where the choice may be both possible and random, would be prior to the formation of the cause.

Klaus Brunner and Bert Klauninger ("An Integrative Image of Causality and Emergence") suggest that the notion of emergence means that a system is more than the sum of its parts and that a developing system has new qualities that can´t be reduced to old states or prior existing systems. Elements of what they call a "strong" emergentist thinking as opposed to a reductionistic "weak" emergentism would be hierarchy, downward causation, incomplete determinism, irreducibility and unpredictability. They develop an integrative image of causality where the influence of the old on the new is equal to the Aristotelian causa efficiens, the influence of the new on the present is corresponds to the causa finalis, the influence from the micro-level (parts) of a system to the macro-level (whole) is equal to the causa materialis and the influence from the macro-level to the micro-level corresponds to the causa formalis.

Rainer E. Zimmermann ("Decentralisation as Organising Principle of Emergent Urban Structures") discusses general organising principles of emergent structures in social systems with a view to the meaning of decentralisation. He proposes to introduce decentralisation as a principle for organising emergent structures in a generic way. Emergence would be closely related to innovation considered as appearance of a phenomenon that cannot be inferred within a utilised language describing some process level, although the language is completely specified. Emergence would refer to models rather than to processes. Detailed behaviour of individuals who comprise a given social aggregate would not be retraceable in the observed collective behaviour of that same aggregate. Individuals would depend on their essentially *local* knowledge produced by *local* interactions (on their microlevel) so that the *global* outcome would generically be a result of superposition, not strictly independent of a single action taken, but in any case *different* from it. Social processes would be computational processes, there would be strategic choices that are based on an inventory of available algorithms that is explicitly determined by the process of socialisation. Centralized organisation would have major drawbacks as compared to decentralised organisation. Zimmermann discusses basic aspects of visualising and modeling the evolution of a macroscopically observable urban structure as the outcome of a superposition of social actions.

Annette Schlemm ("An Integrated Notion of Law") works out a dialectical notion of law. She defines a law as a universal-necessary, essential connection and shows that the statistical and the dynamical view of the law are connected: in the synchronous description of a complex system (i.e. self-reproduction) a law determines one possibility for the behaviour of the system necessarily, there is an objective field of possibilities for the behaviour of the elements, from which one possibility will be realised by chance. She calls this the integrated notion of law. In the diachronic description of a system, new possibilities and a new field of possibilities emerge in points of bifurcation. There is a systemic hierarchy in the synchronous view and an undetermined transition from certain states to others in the diachronic view. She assumes that the dialectical, developing character of the world means that also laws evolve, change and hence have a history.

Yuriy Myelkov ("The Spontaneity of Emergent Events and the Formation of Facts") considers the notion of event and fact in different scientific worldview. He argues that in classical science a scientific fact was considered as an event that is mechanistically determined by laws. In non-classical science an event first would have to be observed in order to obtain a scientific fact and the process of observation influences the formation of facts. In this pardigm an event would no longer be fully determined, it would rather be a chance event. Post-non-classical science would go a third way beyond determinism and indeterminism. He suggests to consider events as spontaneous in this paradigm, i.e. the causality of their emergence combines chance and necessity. Systemic events and the facts constituted by the human observer would have been considered as united in the classical paradigm, as separated in the post-non-classical paradigm and could now in the new post-non-classical paradigm be considered as separated, but united in a higher level unity (meta-system, meta-observer). Scientific investigation would always be influenced by meta-contexts.

Part 2: Principles of Synergetics

This chapter is divided into three subchapters according to a distinction between different types of self-organising systems. First, general principles of self-organisation are discussed, in subchapter 2 principles of physical self-organisation, in subchapter 3 principles of biological self-organisation, and finally in subchapter 4 principles of social self-organisation.

Part 2.1: General Systems

Vyacheslav Stepin ("Evolutionism, the Anthropic Principle, and New Rationality") points out basic philosophical implications of the emergence of the new scientific paradigm. He conceives self-organisation theory philosophically within what he calls the shift of the scientific paradigm from non-classical to post-non-classical science. The rationality of post-non-classical science would extend the field of scientific reflection on activity and be aware of the relation not only between the knowledge of an object and the specific nature of the means and procedures of activity, but also between this very knowledge and the structure of the goals and values of such activity. Extrascientific humanistic goals, worldview guidelines and an open rationality would be important for this rationality. The sciences of the 20th century would have enabled the constitution of a general unifying theory of science that points out general evolutionary principles. Stepin calls such a theory universal evolutionism and points out that it should be both based on evolutionary ideas and the systems approach. There would be four characteristics of a self-organizing system: 1) thermodynamical openness; 2) non-linear character of the dynamic equations of the system; 3) the deviation from balance exceeds critical values; 4) processes in the system occur cooperatively. Self-organisation would play the role of a process leading to the formation of new structures. Self-organisation theory would point out that all aspects of the world and all system-types are interconnected by general evolutionary principles and it would give us fundamentally new possibilities to form an integral general scientific picture of the world. Considering man as part of cosmic evolution and connected to the biosphere would create the foundation for considering man also as responsible for the state of the world. Self-organisation theory would require to put humanistic meaning into scientific knowledge, an alliance and dialogue between man and nature and the formation of "anthropomeasured systems", i.e. harmonious relationships between people, man and nature, would be necessary in order to solve the global problems of mankind that would have resulted from the development of the technogenic civilisation. The latter would be based on exploitation as its dominant value. The ideas put forward by self-organisation theory would have been anticipated by Russian cosmists like Vernadsky and in Eastern philosophy.

Wolfgang Hofkirchner ("A New Way of Thinking and A New World View") argues that the solution of the global problems requires new ways of thinking and a new world view. The theories of self-organisation would constitute a paradigm shift in science. He identifies four different ways of thinking: a reductionistic unity without plurality, a holistic unity without plurality, a dualistic plurality without unity, and a dialectical, integrative unity in plurality. A world view would have three dimension: approaching the world (epistemology), archetyping the world (ontology), and envisioning the world (axiology). He maps the four types of thinking with the three world view dimensions to identify 15 different ways of thinking in world views. There are reductionistic, holistic, dualistic, and dialectical approaches to epistemology, ontology, and axiology. The philosophy of self-organisation would be based on integrative, dialectical epistemology, ontology, and axiology. He characterises the philosophy of self-organisation epistemologically as reflexive rationalism, ontologically as less-than-strict-determinism, and axiologically as responsible activism. Reflexive rationalism could be understood as a dialectic of explaining and understanding, less-than-strict-determinism as a dialectic of necessity and chance, responsible activism as a dialectic of actualising and virtualising. In order to solve the global problems, strategies in the new millennium would have to be based upon the real-world implications and comprehension implications of the new way of thinking and new world view.

John Collier ("Fundamental Properties of Self-Organisation") discusses basic aspects of self-organisation and makes a distinction between self-organisation and self-reorganisation. In self-organisation new macroscopic constraints would emerge, in self-reorganisation no new macroscopic constraints would be formed. Self-reorganisation would be a process or rearrangement. In self-reorganisation the finally available information would be implicit in the initial state of the system, pre-established possibilities would be worked out, such systems wouldn´t be necessarily complex. Only self-organising system would spontaneously produce new emergent information, entail genuine novelty, be necessarily complex and involve the emergence of new constraints and possibilities. Collier assesses different concepts used in complexity literature and evaluates whether they are closer to his concept of self-organisation or his notion of self-reorganisation. He identifies six necessary conditions for dissipative self-organisation: phase separation, a free energy (exergy) source, the exportation of entropy from the system, the promotion of microscopic fluctuations to macroscopic order, the minimisation of local entropy production, and the maximisation of the efficiency of energy throughput.

Vladimir Budanov and Natalya Savicheva ("Principles of Synergetics") present seven general principles of synergetics, suggesting that the synergetical, self-organising development of complex systems the unity of being and becoming is very important. These principles are: homeostasis, hierarchy, non-linearity, openness, non-stability, dynamic hierarchy/emergence, observeability. They present a general hierarchical model of self-organisation where the emergence of new qualities on a certain level is due to the interactions between an upper and a lower level and point out the importance of scale relativity in self-organising systems. They point out a systemic hierarchy that consists of a micro-, a macro- and a mega-level. The mega level would consist of very slow changing eternal variables that function as order parameters for the macro-level, the authors call them control parameters. Order parameters are considered to be long-living collective variables which set the language of the middle meso-level. The micro-level would be constituted by quick short-living variables. At a bifurcation point the macro-level would disappears and due to synergetic interactions of the micro- and mega-levels a macro-level with new emergent qualities would be created.

Vladimir I. Arshinov and Vjacheslav E. Voitsekhovich ("Synergetic Knowledge: Between the Network and the Principles") interpret synergetics as a scientific revolution that has resulted in a new scientific paradigm. Synergetics could be seen on different levels as a number of particular scientific theories, a general scientific theory and as source for a new world-outlook and philosophy. The connection between these three levels wouldn´t be a hierarchical, rather a cyclical one. Arshinov and Voitsekhovich conceive synergetic knowledge topologically as a multi-dimensional open network. They point out some general principles of synergetics: specific ones (non-linearity, instability, openness, subordination), general ones (becoming, recognition, accord, correspondence, complimentarity), mathematical ones (mathematical becoming, complexity, fractal homomorphism, liberation, duality), and logical ones (logical becoming, fractality, geometricity, local non-predictability, global uniqueness) The synergetic outlook would differ from classical paradigms of thinking because it would feature communicativity, continuous dialogue and openness.

Part 2.2: Physical Systems

Christian Fuchs ("Dialectical Philosophy and the Self-organisation of Matter") takes a look at the philosophical relationship between the dialectical thinking of Hegel, Marx, Engels and self-organisation theory. The substance of the world would be the permanent dialectical movement of matter, i.e. the endless productive self-organisation of nature. Concepts from self-organisation theory such as control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory would correspond to the dialectical principle of transition from quantity to quality. What is called emergence of order, production of information or symmetry breaking in self-organisation theory would correspond to Hegel´s notions of sublation (Aufhebung) and negation of the negation. Self-organisation theory would show that Engels´ *Dialectics of Nature* is still very topical and that dialectical materialism contrary to mechanical materialism and idealism hasn´t been invalidated. It would rather seem to be confirmed that dialectics is a general set of general principles of the evolution of nature and society. Self-organisation theory would put forward an immanent logic of explanation of the world as its own reason and cause, hence the assumption that God exists and created the world wouldn´t be scientifically feasible.

Norbert Fenzl ("Emergence and Self-Organisation of Complex Systems. The Role of Energy Flows and Information") points out fundamental physical aspects of self-organisation. His main focus is the role of matter, energy and information in self-organising processes. The throughput of energy and matter and the production of system-specific information would be the basic driving forces of self-organisation. A complex system would interact with its environment mediated by a field of interaction. Emergence is considered as the *appearance of a new property* of a system which cannot be deduced or previously observed as a functional characteristic of the system, self-organisation as the *appearance of new system structures* without explicit pressure from outside the system, or involvement from the environment. Fenzl points out the process of interaction between two open systems. Each system would change its structural information according to the changes in the field of interaction. He terms the changes caused by a system in the environment potential information. Material and energetic signs would be imported as signals by a system from its environment, these signal would trigger the actualisation of structural information. This actualisation would start in new interactions with the environment that result in a differentiation of pragmatic information. For an interaction of two open systems there would have to be a shared interaction field, a common pool of signs. In systemic interaction the signals imported by one system would be produced by the other system..

Doris Zeilinger ("Spinoza, the "Very Untranscendental". Ernst Bloch´s Interpretation of Spinoza") discusses Ernst Bloch´s concept of matter and his references to Spinoza. Bloch would positively refer to Spinoza´s assumption of a non-spiritual material substratum of the world and would criticise him for a static conception of nature that leaves out movement and dynamics. She shows that Bloch has referred to the assumption of a fully lawfully determined world with the metaphor of the crystal and has been critical of reductionism because he thought that the qualitative human individual was neglected by it. Bloch would have liked Spinoza´s Pantheistic notion of God as immanent in nature. Hence the world would be no creation by God because nature would be its own cause and would produce itself. In this context Bloch, Zeilinger points out, found interest in Spinoza´s concept of natura naturans, i.e. nature as a producing, active subject. Bloch opposes a static concept of matter ("block matter") and considers nature as an open, self-organising process. For Bloch matter would be a dialectically developing, producing substance and this substance would have an immanent and speculative potential. Zeilinger stresses that Bloch´s concept of matter corresponds to and anticipated Prigogine´s and Haken´s concepts of self-organisation. She also stresses that Bloch´s philosophising has its beginning as well as its end in the human existence and that hence Bloch puts forward the idea that the human being in co-operation with nature can advance humanistic ideals. A strong teleological humanistic element would be constitutive for Bloch´s works.

Part 2.3: Biological Systems

John Collier ("Organisation in Biological Systems") points out aspects of biological self-organisation. He argues that both the etiological and the organisational approach on biology have serious shortcomings and proposes a reconciliation that is based on an interactivist approach. The etiological approach would be an externalist one, the organisational an internalist one. A satisfying concept of biological self-organisation would have to combine both internal and external aspects. Based on such a synthesis he develops the concept of biological autonomy. Maturana´s concept of autopoiesis would suffer from mechanism, mostly because of its closed, internal character. But self-organising systems would be intrinsically open systems, autonomous biological systems would be open to information as well as energy and matter. This would be denied by the definition of autopoiesis. Autonomy would require non-equilibrium conditions, internal dynamical differentiation, hierarchical and interactive process organisation, incomplete closure, openness to the world, and openness to infrastructural inputs

Part 2.4: Social Systems

Christian Fuchs and Gottfried Stockinger ("The Autocreation of Communication and the Re-creation of Actions in Social Systems") point out fundamental aspects of social self-organisation. Social systems and the human being would be creative, communications and human actions would be important aspects of social self-organisation. Social systems would be auto- and re-creative systems: from the perspective of communication, social self-organisation would denote the permanent creation of reality through concatenation of communication units in a self-referential mode (auto-creativity). From the perspective of the human actor, social self-organisation would denote a permanent reflexive interaction process related and coupled to social structures (re-creativity) where social structures are medium and outcome of social actions. Auto-creative communications and re-creative actions would be mutually dependent and coupled and together would enable the self-organisation of social systems and society. The main argument of Fuchs and Stockinger is that the creativity of social systems is based on autopoietic or self-reproducing processes on both the level of communications and the level of actors and that on both levels creativity is an important feature. They argue that co-operative social self-organisation could be a principle that puts forward co-operative intelligence (CI).

Franz Ofner ("Action, Communication, and Creativity. A Contribution from a Meadean Perspective") points out that if there is a transition from action to communication and vice versa these two kinds of processes need to have common contents and structures, hence the question would arise how understanding between actors and meaning is possible. He deals with these questions from a perspective that is based on the works of George Herbert Mead. The first step towards consciousness of meaning would take place if the gestures are such that the individuals making them can perceive them. This would be the case with vocal gestures. As a result the individual making the gesture would be enabled to participate in the other´s response. The consequence would be that the individual assumes the same attitude towards his own gesture as the other individuals do. This procedure of taking the attitude of the others towards his own gestures would be the core of Mead´s approach to explain the appearance of meaning and consciousness. The gesture would call out in the individual making the gesture the image of the response of the other individual. The individual would respond to his own gesture in the form of imagery. Thus, the connection between gesture and response would be internalised, and would become conscious and meaningful. Significant gestures would emerge. The procedure of taking the attitude of the others would enable the individuals to create a self and social objects which are internalised. Thinking would arise if communication processes take place within the organism of individuals in the sphere of imagery. Ofner argues that formation of meaningful gestures and the self is the precondition for human creativity and reflexivity which are fundamental aspects of social self-organisation.

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References:

Collier, John (2003) Fundamental Properties of Self-Organization. In this Book.

Collier, John (2004) Self-Organisation, Individuation and Identity. In: Revue Internationale de Philosophie (forthcoming). http://www.kli.ac.at/personal/collierpdf/SOIIF.PDF

Corning, Peter A. (1998) The Synergism Hypothesis. In: Journal of Social and Evolutionary Systems, 21(2), pp. 133-172.

Edmonds, Bruce (1999) What is Complexity? - The Philosophy of Complexity per se with Application to Some Examples in Evolution. In: Heylighen, F./Aerts, D. (Eds.) (1997) The Evolution of Complexity. Dordrecht. Kluwer.

Flood, R. L./Carson, E. R. (1993) Dealing with Complexity: An Introduction to the Theory and Application of Systems Science. New York. Plenum Press.

Goldstein, Jeffrey (1999) Emergence as a Construct: History and Issues. In: Emergence 1, 1, pp. 49-72.

Heylighen, Francis (1996) What is Complexity? http://pespmc1.vub.ac.be/COMPLEXI.html

Heylighen, Francis (1997) The Growth of Structural and Functional Complexity during Evolution. In: Heylighen, F./Aerts, D. (Eds.) (1997) The Evolution of Complexity. Dordrecht. Kluwer.

Kauffman, Stuart (1993) The Origins of Order. Oxford. Oxford University Press.

Kuhn, Thomas (1962) The Structure of Scientific Revolutions. Chicago. University of Chicago Press.

I. Causality and Emergence

Cause of Emergence or Emergence of Cause?
Irina Dobronravova

In order to discuss the problem of causality in connection with the problem of emergence, we have to define emergence. If we talk about the emergence of new integrity in synergetics, we have to regard unity through diversity as a process.

Emergence could be a process of self-organisation in the sense of the becoming of a new whole, making its parts the elements of the non-linear medium (the becoming of the parameter of order). It could be the dynamically stable periodical reproduction process of the self-organised, self-sustained whole (the movement of the parameter of order along the limit cycle). It could be the transition of the parameter of order to chaotic behaviour.

Altogether these above-mentioned phases of the evolution of a complex system create unity through diversity by themselves, because of the different features of this process in its different phases. Let me remind you that a system in a bifurcation point has a high sensitivity to small accidental influences, which can define its further destiny. Nonetheless, in the next phase much more intensive disturbance cannot destroy the dynamically stable existence of the self-organised system.

At the same time, though a choice in a bifurcation point is a choice by chance, it is a choice between two certain possibilities (there is a set of a few certain possibilities for the critical point in general). These possibilities are defined by attractors of the non-linear medium. And, just an appearance of such choice is by itself a sign of the integrity of the medium in which self-organisation takes place. This choice emerges together with the emergence of the parameter of order and only for the functioning of this parameter.

Prigogine spoke of so-called ”long range order” (Prigogine, 1980) that characterises long-scale fluctuations. These are not small fluctuations that can be understood as derivations from average values of the microscopic characteristics of the medium´s elements, which are destroyed by collisions between near-by neighbours in their chaotic movement, that provide respective macroscopic parameters of the previous state, described by the thermodynamic curve until the critical bifurcation point emerges. We do not at all find the average values in the critical point; there are only two possible variants of coherent movement of the elements, corresponding to different values of the becoming parameter of order.

Thus, integrity is an immanent feature not only of self-organised systems, which are developing and becoming as a result of the historical choice between the two possible variants of coherent movement of the elements of the non-linear medium. The emergence of a set of possibilities for becoming parameter of order, is a sign of integrity in a synergetic way.

So, integrity and the presence of alternatives do not exclude, but pre-suggest each other. This is far more evident for mediums in which both variants of choice can coexist. For each element of a medium only one choice is carried out (one of vortexes for the molecule, the choice for one political parties for the citizen), but all possible variants can be realised in the entire medium. It is important that not any possibilities exist in a non-linear medium, but strictly certain ones, and just this means the emergence of integrity.

Such an understanding of integrity associates a similar understanding of integrity of a quantum mechanical system. In both cases we can theoretically reconstruct the set of possibilities that characterises the system as a whole. In both cases the possibilities appear themselves in further measurements or in further realisation of the non-linear dynamic. In both cases we are dealing with choice by chance. However, in quantum mechanics the choices are limited by statistical laws, whereas in synergetic events choice exists besides regularities, defining the choice between them.

The meaning of integrity, characterised by the presence of the parameter of order, is preserved during all phases of the self-organisation processes. Even after the transition of the parameter of order to chaotic behaviour, you will find the parameter of order. (Haken 2000) It will continue to define the coherent movement of many elements of the medium, although on the surface of being we can watch the destroying of previously integrative structures.

So the initial point of emergence of novelty is the emergence of the medium´s integrity. It appears as an emergence of a set of possibilities for further choice by long-scale fluctuations. Prigogine called such fluctuations the cause of new order (Prigogine 1980). Then it is naturally to understand the previous state of the non-linear medium in the critical (bifurcation) point as the situation of the formation of causes.

It can be understood in Hegelian terms of cause formation from the second part of the "Science of Logic". Then choice by chance in the bifurcation point defines a "real necessity", which "contains the chance" of the previous choice. So the choice precedes the emergence of efficient cause. Non-linearity by itself can be considered as a ground of self-organisation and the critical value of the control parameter as its condition (Dobronravova 1997). Both ground and conditions determine the emergence of fluctuations as efficient causes of the becoming of the new wholes. For Hegel, the substance plays a role of cause so far as it has the power to “generate the action, the reality”. (Hegel 1974: 180)

Such an understanding gives us the opportunity of avoiding a paradoxical look at events, like considering a cry in the mountains as the cause of an avalanche. The emergence of a non-linear state of snow or stones as a ground of formation of the efficient cause of an avalanche provides accidental events, like a cry, with the meaning of a critical condition of choice by chance of the cause and the effect

It is strange to say that such a consideration fully corresponds with the understanding of efficient cause in classical physics, i.e. physics of Galileo and Newton. As is known, they only regard the cause for a change of movement and consider force as this cause. To change the state of mechanical movement power is needed. We have a similar situation in non-linear studies: to produce new structures we need power: a flood of energy that comes into the medium or is produced by it.

The problem of causality in synergetics can also be discussed in Aristotelian terms by using all the types of causes offered by Aristotle. Kurdumov (Kurdumov 1994) considers the attractors of non-linear dynamics as a sort of final cause. Material cause is evidentially corresponding to the far-from-equilibrium state that is typical for a non-linear medium and that comes along with streams of energy and entropy throughput in the open system. And formal cause can be adequately understood in the context of regarding all kinds of causes. The cry in the mountains can be regarded as the formal cause of the avalanche, if we take in account material and final causes. Then the efficient cause will be the result of the combined action of all other causes.

Despite the way of interpretation, shifting attention from cause of emergence to emergence of cause, we can avoid the consideration of the situation of bifurcation as an effect of the previous state. The previous state to bifurcation point is not a critical state yet and for the first bifurcation it is not even a non-linear one, so it cannot play the role of a cause to appearance of bifurcation. Klaus Brunner and Bert Klauninger (see their contribution in this book) have shown that attempts of regarding the previous state to bifurcation as its cause lead to a weak version of determinism. In my opinion a bifurcation point has to be considered as a point of the formation of causes. Here the system makes a random choice between two equally probable solutions. It is the fluctuation, which "selects" one of two solutions of equations possible at a certain critical parameter value (condition), that can be understood as the cause, whose action is the formation of a coherent structure, i.e. the choice by the system of a certain evolutionary pathway. Hence the situation, where the choice may be both possible and random, is prior to the formation of the cause.

In dynamic chaos each step of the non-linear dynamic is connected with a critical point. Concerning the emergence of fractals in the area of the concurrence of different attractors, I am not sure if we can positively refer to Hegel or Aristotle in order to achieve a right formulation of the causality problem.

The determination of each step of non-linear dynamics with the help of iteration formulas in non-linear studies does not provide the possibility of long-term prediction due to the influences of small differences in parameter values (these differences already exist at least because of quantum fluctuations). However, the importance of Mandelbrot sets is general enough, so that the definiteness of possible variants of complex structures requests a comprehension, but may be it should not be obviously done in terms of causality.

References:

Dobronravova, I. (1997) Dialectic as a Means for Understanding Nonlinear Science. In: Dialectic, Cosmos, and Society, No. 10 (1997), pp. 7-15.

Haken, H. (2000) The Main Notions of Synergetics (Synergetic Paradigme). Moscow. Progress - Tradition.
pp.28-56.

Hegel, G.W. F. (1974) Wissenshaft der Logik. Berlin. Academie

Kurdumov S..P./ Knyazeva E.N. Laws of Evolution and Self-Organisation of Complex Systems. Moscow. Nauka.

Prigogine, I. (1980) From Being to Becoming. San Francisco. W.H.Freeman and Company.

An Integrative Image of Causality and Emergence

Klaus A. Brunner and Bert Klauninger

In this paper, we describe our idea of an integrative image of emergence and causality, showing that Aristotle´s four kinds of causes can serve as the basis of a modern integrative theory of emergence about the new-old and whole-part relationship. Brief historical overviews of the concepts "emergence" and "causality" are given to explain and support this view.

1. A Brief History of "Emergence" as Concept and Theory

1.1. Introduction

In any discussion of emergence, it is of vital necessity to *define* the term in the first place: the word "emergence" has become overloaded with an abundance of different meanings – some of them vague, weak, and unspecific; some of them precise, strong, and implying a number of very specific theories about our world. The main goal of this chapter is to give an overview of what emergence means, and even more importantly, what it does not mean.

First, it is important to draw the line between "emergence" as a mere synonym of everyday language words like "appearance" or "growth" on the one hand , and "emergence" as the fundamental concept of emergentist theories in philosophy on the other hand. We are only interested in the latter. Without getting too specific at this early stage, it is possible to outline some general properties of emergentist philosophy:

1. Emergentist theories make statements about the world: its current state (or "being") – the synchronous aspect; and its historical development and evolution (or "becoming") – the diachronous aspect.
2. The *synchronous* aspect is characterised by the idea that a whole (or system) can have genuinely different properties than its parts. For instance: table salt is not merely the sum of the properties of sodium and chloride; a brain is not merely the sum of many neurons (brains think, neurons do not). There is the important assertion that some properties of the whole cannot be explained by, or deduced from, the properties of the parts. Such properties are emergent, as opposed to resultant properties.
3. The *diachronous* aspect deals with the appearance of new things with new properties over time. In short, the assertion is that genuinely new things with genuinely new qualities develop, or evolve, from old (and usually simpler) things and their qualities. These new properties cannot be predicted from even perfect

knowledge of the old properties. For instance: a long time ago, a primordial soup gave birth to the first cells, some cells formed organisms, some organisms developed group behaviour and even consciousness.

These examples show that emergentism is interested in qualitative change, not just quantitive change: the development from "one amoeba" to "millions of amoebae" would not be considered as emergent. For both synchronous and diachronous aspect, the relation between parts and wholes is of central importance.

1.2. Competition

Having sketched a rough outline of what emergentism *is*, it is instructive to stake its borders by showing what it is *not*. Emergentist philosophy in the modern sense can be traced back to the beginning of the 20th century[1] and its main proponents Conwy Lloyd Morgan, Samuel Alexander, and Charles Dunbar Broad. At the time, it was posited as an alternative to other philosophical programmes, some of which are still relevant today.

1.2.1 Reductionism

Just like emergentism, reductionism comes in a variety of (somewhat) different theories. There is one integrating principle of reductionism, though, which may be summed up as "the parts are more important than the whole", or "the whole is result of the parts", or "the parts explain the whole". Reductionism is the theory behind *analysis*, the methodology of explaining wholes by looking at their parts. Reductionism has been extremely successful in science, so successful that some reductionists see no reason to deem it universally applicable and "all we ever need" in science. An extreme reductionist position is that everything, from quantum physics to sociology, could – at least in principle, and given enough time and computing power – be explained by a few laws of particle physics. Anything else is actually resultant or epiphenomenal. This is a strong form of "reductive physicalism", the main competitor of emergentist philosophy.

For the emergentist philosopher, reductionism is not completely wrong – it would be foolish to ignore all the impressive evidence of successfully applied reductionism. However, the typical emergentist would deny the universality or

[1] However, some researchers claim that the first traces of emergentism can be found in ancient Greek philosophy, some see its roots in the philosophy of John Stuart Mill (1806-1873). See (Stephan 1999) and (Blitz 1992) for detailed historical analyses.

completeness of reductionism: while some (or even many) things can be reduced and explained by their parts, some things can not. This is not a limitation of our time or computing power (as the reductionist might reply) or anything else on the observer´s part, but a limitation of how the world is: some things cannot be reduced, some properties are not mere results of the parts´ properties. In other words, some wholes have emergent properties, and all the time, computing power and knowledge of Laplace´s demon would not suffice to break those properties down into the properties of the parts.

1.2.1. Holism

Holism is – to some extent – the mirror image of reductionism: the holist asserts that the whole takes precedence over the parts. To understand the whole, knowledge about the parts is neither sufficient nor necessary; the parts are results of the whole.

Emergentism does have some overlap with holism, yet it is important to be aware that they the two philosophies are not identical[2]. Emergentists agree that wholes (or "higher level entities") are not always mere results of their constituent parts, but as already noted above, they do not go as far as saying that it is just the wholes that matter. Jan C. Smuts, a well-known holist of the 1920s, was well aware of Lloyd Morgan´s emergentist theories and the differences to his own work:

"To [Lloyd Morgan] emergence of the new in evolution of the universe is the essential fact; to me there is something more fundamental – the character of wholeness, the tendency to wholes, ever more intensive and effective wholes, which is basic to the universe, and of which emergence or creativeness is but one feature ..." (Smuts 1927 : chapter V)

In emergentism, wholes (or "systems") can and do have special properties, but there is no inherent tendency to wholeness or "whole-making".

1.2.2. Dualism

Dualism, as first described by Descartes in the 17th century, appears as an attempt to reconcile mechanism (and reductionism) with the existence of the divine: on the one hand, the world and its inhabitants are mere automata, like robots; on the other

[2] The line between emergentism and holism is often blurred or even denied in literature. For instance, *The Oxford Companion to Philosophy*´s entry for "holism" cites C. Lloyd Morgan as a proponent of holism (1995 edition).

hand, there is a completely different world of spirit. These two separate, independent realms (*res extensa* and *res cogitans*) meet in but one place: man´s brain, where the spirit has causal influence on human thought and actions.

A somewhat curious variant of dualism is Leibniz´s *parallelism*, which states that completely mechanistic physical and spiritual worlds exist in parallel, each matching the state of the other, but with no causal connection between them. The usual illustration for this is that of two identical clocks which are started at precisely the same time: both clockworks will behave identically, both clocks´ hands will show exactly the same time, anytime – and yet there is no causal connection between them (see Schleichert 1992 for a more extensive discussion of dualism).

Dualism in these extreme forms has no serious support these days, but milder forms of dualism are still part of Western thought, as shown by the widespread notion of separated "body and soul". Though it may seem there is virtually nothing that emergentism has in common with dualism, the problems implied by Descartes´s mysterious causal interaction between *res extensa* and *res cogitans* are quite similar to those of an important part of emergentism, namely, downward causation (see below).

1.3. Elements of Emergentism

1.3.1. Hierarchy

A typical element of emergentist thinking is the assumption that the world is structured in higher and lower "layers" of existence. These may be global and absolute (as in the distinction between physical, chemical, and biological layers) or local and relative (as in "any system versus its parts") ones, and the borders between them may be fuzzy or discrete.

This assumption is not unique to emergentism: even the most extreme forms of reductionism imply some form of layered hierarchy, if only in a descriptive sense[3]. The main differences between reductionism, emergentism, and holism are the different ontological roles assigned to the layers of hierarchy. For the radical reductionist, there is only one "real", causally relevant layer – the lowest (e.g., the realm of particle physics). All "higher" layers of hierarchy are mere descriptions of

[3] One might say that reductionism *requires* hierarchy: there must be something on a higher level to be „reduced" to a lower level.

lowest-level events, with no causal power of their own. For the radical holist, it is the other way round.

Emergentism is the middle ground between the two extremes of reductionism and holism: different layers can have causal powers of their own, but they are never completely independent of each other – there is always a coupling between higher and lower levels. Blitz (1992:179) puts it very aptly: “Emergent properties are anchored in structures, and do not exist independently of them, though they are not reducible to them.”

1.3.2. Downward Causation

Downward Causation (DC) is another important element of emergentism[4]. In short, downward causation is what gives emergent properties causal powers: for instance, one might assume that mind (or conscious thought) is an emergent property of the brain, and that it has a causal power of its own. Otherwise, mind would be a mere result of lowest-level cell activity, a seemingly random pattern of no more causal significance than any other pattern in the world.

The main question is: what kind of causal power? What can higher levels do to influence events at lower levels? Most emergentists would deny a strong form of DC that gives higher levels the power to break or change the laws of lower levels: the laws of physics hold in any physical system, even if it constitutes a chemical or biological system. More commonly, emergentists see downward causation as the generation of constraints or boundary conditions for events at a lower level: DC selects from the possibilities given by the lower level.

1.3.3. (In-)Determinism

Does emergence require some form of indeterminism? The answer of mainstream emergentist philosophy would be a clear no, if the question is considered important enough at all (cf. Stephan 1999: 26). Emergentism states that genuinely new properties appear over time, and that it is not possible to predict them *before they have appeared for the first time*.

[4] Note that some authors use the term ”supervenience“ as a synonym of downward causation. Unfortunately, supervenience has taken on a different connotation that does *not* necessarily imply downward causation. See Kim (1993), Andersen et al. (2000).

To illustrate this point, let us consider a number of elements $E_0...E_n$ with well-known properties $P_0...P_n$. When these elements are put together to form some system S, the system will exhibit some resultant properties (which can be deduced from the elements´ properties, and therefore predicted before the system is actually built) and possibly some emergent properties (which can not be deduced from $P_0...P_n$, and which are therefore impossible to predict). However, the occurence of emergent properties is deterministic and therefore repeatable: building another system S´, of identical structure, from identical elements will result in exactly the same properties, resultant and emergent, as the first system.

There are, however, other emergentists with differing views on determinism, such as Karl Popper and his "propensities" (Popper 1995) and Wolfgang Hofkirchner and his "incomplete determinism" (Hofkirchner 2001).

1.3.4. Stephan´s Taxonomy of Emergentism

Achim Stephan´s summary of (mainstream) emergentist concepts is a useful overview of emergentist ideas. His model starts with the common denominator of emergentistic thinking, called "weak emergentism". It is characterised by three postulates:

- Physical Monism: the world consists of one (physical) substance. There are no supernatural powers or entitities.
- Systemic Properties: systems may have properties that none of their parts have (e.g., a living system consists of non-living parts, a speaking human consists of non-speaking cells).
- Synchronous Determinism: the properties of a system are coupled to its microstructure. There is no change of the system´s properties without change of its structure or properties of its parts (this is the "anchoring in structure" described by Blitz, above).

We argue that this "weak emergentism" is practically indistinguishable from reductionism, so the word "emergentism" seems to be inappropriate here unless the two stronger conditions of emergentism apply:

- Irreducibility: the essence of the synchronous aspect of emergentism. Some properties of a system are not reducible to properties of its parts.
- Unpredictability: the essence of the diachronous, evolutionary aspect of emergentism. This may be the logical result of either irreducibility (if the systemic property cannot be deduced from the parts´ properties, it cannot be

predicted) or indeterminism (if the systemic property is not determined *ex ante*, it cannot be predicted).

In order to analyze the connection between necessity and randomness, between determinism and indeterminism, between causality and emergence, it seems convenient to take a diachronous look at the development of different causality conceptions during the ages.

2. The Historical Development of the Notion of Causality

2.1. Introduction

The idea of causality is based on our belief that events in the universe are interconnected. Classical (linear / monocausal) sciences use the term “cause” for the first of two interconnected events and the term “effect” for the other. So the idea is that events occur in a special temporal order (*post hoc ergo propter hoc*). This conception is hardened by our perception and experience, and it seems that the conception of causality is crucial for creating models of the world and hence for practising sciences at all.

Of course there are several positions that doubt that the term causality has an ontic meaning at all. The positivist approach stresses that causality (just like any other metaphysical conception) is merely an illusion. Every statement we can meet has to be related to sensual perception and so each sentence can be reduced into sentences about sensual data. Causality does not correspond to anything in our direct perception. Because events occur in the same temporal order several times, the human mind is generalizing this perception and constructing categories of cause and effect (Hume, Berkeley, Locke). Neo-Positivism (the Vienna Circle – Carnap, Schlick, Popper ...) took up these ideas and stated that there is no evidence for any causal relationship in the universe. Later, Popper developed his concept of propensities where he returned to the objective existence of causes.

2.2. The Mythic Age

At early stages of human thinking, the introduction of metaphysical entities to explain some otherwise not explainable events was quite common. Examples for such attempts to explain the world would be Babylonian (Gilgamesh), Egyptian and ancient Greek myths – but also the myths of monotheist religions.

Around 800 BC Homer depicted the world view of an archaic epoch. The myths that accumulated in Ilias and Odyssey had been passed on for ages before Homer wrote them down. Here we encounter a world-view where human beings are not self-determined but merely playthings of spiritual entities ("gods"). These gods form anthropomorphic principles (Poseidon = sea, Ares = war, Athena = intellect, Hades = death ...).

Spiritual entities are fighting against each other and during these fights they are making up our fates as human beings. The order of the world *per se* can not be entirely recognized. The only kind of knowledge that may be acquired is technical knowledge (e.g. Hesiod).

2.3. The Birth of Science

Around 600 BC a new school of philosophy appeared – Philosophy of Nature. Since Thales, Amaximenes, and Parmenides new requirements had formed a central part of all sciences:

- *Empiry:* every woman/man must (in principle) be able to verify the truth of any statement by her/his own sensual cognition.
- *Congruency:* new statements have to be consistent with all other contents of our consciousness which are the result of earlier empirical or cognitive acts.
- *Universality:* the truth of a given statement is independent of its temporal and spatial context (*sub specie aeternitatis*)

Within the conception of early Atomists (Democritus, Leucippus) the first reductionistic/mechanistic approach in history was formulated. In this model, only empty space and atoms exist whereas all other properties of the universe (colour, taste, mind) are merely illusions of our senses. Nothing exists despite of atoms (material cause) and their trajectories in empty space (efficient cause). Events in the universe can be sufficiently explained with collisions of those atoms.

2.4. Aristotle

Around 400 BC Aristotle, scholar of Plato, perhaps the most universal of all philosophers, appeared on the stage of science. Besides his famous works about formal logics (*Organon*), physics and biology (*Physica*) Aristotle also tried to formulate general principles of being, a *prima philosophia*, as a ground for all other scientific work (*Metaphysica*). So he was one of the first philosophers to explicitly deal with causality.

He considered all of the previous conceptions of cause as insufficient. His teacher Plato explained causality only through substance (ideas) and hence reduced everything to "material" causes, even if matter is an idealist concept here. Pythagoras as well as the Eleates (Parmenides) focused only on the formal conditions. Heraclites and the Atomists took only linear cause-and effect relationships into account. And besides mythology and mysticism (which appeared only very rarely in ancient Greece), no one had dealt with purposes, targets, i.e. with final causes.

So Aristotle formulated his well known concept of four combined causes:

causa materialis
causa formalis
causa efficiens
causa finalis

2.5. The Middle Ages

Aristotle had huge influence on medieval scholasticism, namely on Thomas of Aquino, Nicolas of Autrecourt, Augustinus and others. As the middle ages were a very selective epoch, only those antique authors whose ideas were compatible with the dogma of the Roman Catholic church could survive. The most important cause for the influence Aristotle had on medieval philosophy was perhaps his consideration of final causes (God). Nevertheless, the image of causality which was used in scholasticism was an idealist reduction on only formal and final causes.

The dogma was a huge obstacle for the development of sciences, and it took several hundreds of years to break with it. One of the most important criticists of scholasticism was William of Ockham. He was a pioneer of a new paradigm (Ockham´s Razor) that has been part of scientific methodology ever since: Entities should not unnecessarily be multiplied. From two possible explanations for a phenomenon, the simpler one shall be used. This resulted also in a revival of efficient causes.

2.6. Renaissance

From the dawning of the modern age, scientists and technicians where successful in reducing causality to efficient causes that operate in a strict deterministic way. Galileo defined the paradigm to measure everything that is measurable and to make everything measurable that is not. Galileo, Kepler, Newton and many others were very successful in describing the universe using this reduced mechanistic worldview. Descartes introduced strict determinism into the methodology of science, and La Place stated that the universe was comparable to a clockwork of infinite precision. If some being observed the universe at any point of time with arbitrary precision, she/he could calculate the state of the universe at any other time, be it in the future or the past (La Place´s demon).

This paradigm of calculability, determinism and monocausality dominated the sciences until the beginning of the 20th century, and even today not all scientists are aware of the shortcomings of this worldview.

2.7. Paradigm Shift

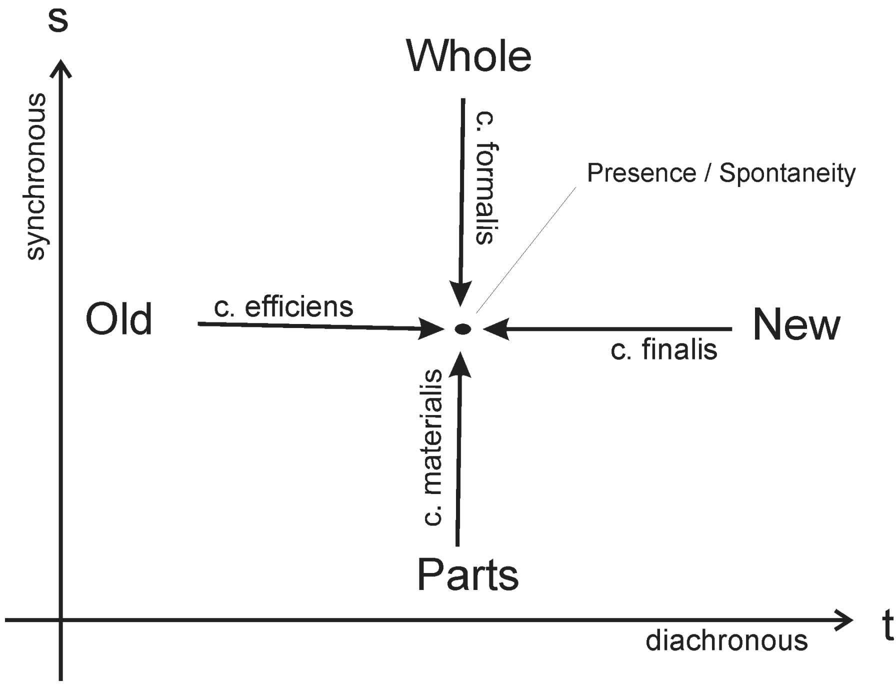
Since the end of the 19th century, monocausal approaches in many different sciences started to collapse. Even in pure mathematics and logics, problems with the calculability of the universe arose (e.g. Russell´s paradox). Hilberts program failed with Kurt Gödel´s proof. At the level of physics, many different problems (ultraviolet catastrophe, wave-particle dualism ...) lead to the development of new physics. Einstein´s relativity theory is definitely a classical (mechanistic/deterministic) theory and despite of the fact that he contributed to the emergence of quantum physics, he was always looking for a hard deterministic explanation, but (of course) never found one.

At the level of biology, several experiments showed that many aspects (as foetal development) cannot be explained deterministically, and Hans Driesch postulated the existence of some *elan vital*, a kind of energy which existed only in living organisms (vitalism). Ludwig von Bertalanffy sketched the possibility of a "third way" between mechanism and vitalism. Let us keep in mind that this has lead to the development of the "Allgemeine Systemlehre" (general systems theory) and to the *organismic* worldview. Nevertheless, general systems theory is not biologism – it´s an ontology and epistemology which tries to define common properties of all systems at a very basic level.

In psychology, the introduction of the natural scientific methodology lead to Behaviourism and the theories of condition which have been used successfully in manipulating people (media, marketing, politics) ever since. Bertalanffy was a vehement criticist of the approach to view a living being as a black box because phenomena like consciousness, the unconscious, feelings, perception, cognition are neglected in Behaviourism. Also in psychology and sociology a paradigm shift took place and nowadays it does not seem opportune to take a strict Behaviourist view any more.

3. Proposal for an Integrative Image of Causality

One major task is to unite complex causality with the possibility of the emergence of novelty. So the new image cannot be a strictly deterministic one. Another task is to depict the connection between the two aspects of emergence (synchronous, diachronous). Our proposal is as follows:



On the diachronous axis (along the timeline) emergence is the spontaneous appearance of something new that cannot be sufficiently described through deterministic development of the old. Synchronously, the parts (micro-level, subsystems) are necessary but not sufficient for explaining the whole (macro-level).

The influence of the old on the new is equal to the Aristotelian *causa efficiens*. A reduction to only efficient causes leads to classical determinism. The new (as an aim or target) has as well influence on the present (*causa finalis*) – a reduction would lead to esoteric fatalism where the future (e.g. Omega Point or Hegel´s absolute spirit) determines the past.

The parts on the micro-level form the material (*causa materialis*) of which the whole consists. If we claim that the macro-level is completely explainable by the micro-level, this leads us to reductionism. On the other hand, there is the influence from the whole on its parts (downward causation, dominance, enslaving – *causa formalis*) as the whole is constraining the actions of the parts.

It seems important to state that the notions "old-new" and "part-whole" are relative to the position of the observer. Each component of the micro-level can bee seen as an own macro-level depending on the scale applied.

We think that the four points in our diagram should not be regarded as different "poles" but as four aspects of the same thing: causality. At a micro-level of our theory, efficient and final causes are dialectically sublated to form a diachronous view. Material and formal causes are dialectically sublated in the synchronous view. And at the macro-level of our theory, synchronous and diachronous view are sublated in the general term causality which includes the possibility of emergence as all four causes are operating in a process of constraining and enabling which is not strictly deterministic.

References:

Andersen, P./Christiansen, P./Finneman, N. (Eds.) (2000) Downward Causation: Minds, Bodies, and Matter. Aarhus University Press.

Aristotle (1994) *Metaphysik*. Reinbek bei Hamburg ´Rowolth.

Bertalanffy, Ludwig von (1949) *Das Biologische Weltbild*. Bern. Böhlau.

Bertalanffy, Ludwig von (1970) *Robots, Men & Minds*. Düsseldorf/Wien. Econ.

Blitz, David (1992) *Emergent Evolution: Qualitative Novelty and the Levels of Reality*. Dordrecht. Kluwer.

Corning, Peter A. (2002) *The re-emergence of emergence: a venerable concept in search of a theory*. Manuscript.

Hofkirchner, W. (2000) *The hidden ontology : real-world evolutionary systems concept as key to information science*. In: *Emergence* 3.3 (2001)

Kim, J. (1993) *Supervenience and Mind*. Cambridge Univ. Press.

Klaus, Georg/Buhr, Manfred (1974) *Philosophisches Wörterbuch*. Leipzig. VEB.

Klein, Hans-Dieter (1993) *Metaphysik*. Eine Einführung. Wien. Literas.

Popper, Karl (1995) *Eine Welt der Propensitäten*. Tübingen. J.C.B. Mohr (Paul Siebeck).

Russel, Bertrand (1996) *Denker des Abendlandes. Eine Geschichte der Philosophie*. Bindlach. Gondrom.

Salthe, Stanley N. (1993) *Development and Evolution. Complexity and Change in Biology*. Cambridge/London. MIT Press.

Schleichert, Hubert (1992) *Der Begriff des Bewusstseins. Eine Bedeutungsanalyse*. Frankfurt am Main. Vittorio Klostermann.

Smuts, J. (1927) *Holism and Evolution* (2nd edition). London. Macmillan.

Stephan, Achim (1999) *Emergenz: Von der Unvorhersagbarkeit zur Selbstorganisation*. Dresden. Dresden University Press.

Decentralisation as Organising Principle of Emergent Urban Structures[1]

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Abstract

As to the main topic of our ongoing INTAS cooperation, in the following a number of basic aspects of the concept of emergence are being listed utilizing an example from a research project presently undertaken which deals with urban structures. This example may serve as a straightforward illustration of the epistemic universality of the approach introduced here, giving an impression of the relationship between the observed world and its foundations on the one hand, and drafting the methodology relevant for the wide range from physics to politics, on the other. In particular, with a view to the ongoing Bologna project (www.arXiv.org/pdf/nlin.AO/0109025), general organizing principles of emergent structures in social systems are being discussed with a view to the meaning of decentralization. It is proposed to introduce decentralization as a principle for organizing emergent structures in a generic way utilizing aspects of the insight gained by the Santa Fe school dealing with self-organized criticality. The techniques actually utilized come from graph theory, category theory, and in particular quantum gravity, which bear a strong potential for a multitude of applications in research fields with a significant interdisciplinary scope. This is especially important for applications in the organisation of social systems which usually call for an interaction of logic and hermeneutic.

1. Introduction: The Mediation of Micro- and Macrolevels

When dealing with the emergence of structures, the phenomenon of emergence itself, and the concept of emergence we derive from it, point mainly to a systematic deficiency of inference. In other words, on the one hand, emergence refers to models rather than to processes: Very much like the concept of complexity, the concept of emergence is attributed to the models, not to processes proper. The reason for this is that we never actually deal with the world realiter as it is (in ontological terms), but only with the world modaliter as we model it (in epistemological terms) according to what we perceive. On the other hand, emergence is closely related to innovation. We call a phenomenon innovative, if its

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appearance cannot be inferred within a utilized language describing some process level, although the language is completely specified.

To be more precise: We cannot formulate a model in a macrolanguage, given the microlanguage (Edmonds 1999: 47, cf.: 72). The point is here that we visualize processes as acting on two levels relative to each other, one the microlevel on which a large number of relevant processes take place being performed by individual agents associated with specific actions, the other the macrolevel on which a collective phenomenon can be observed which can be understood as a kind of superposition of all the individual actions being performed on the microlevel. In other words: Observable processes show up on the macrolevel of the world, this level being defined primarily in terms of the perceptive properties of observers. But they „happen" on the microlevel. This is basically true for all possible systems.

But in the case of social systems, the agents on the microlevel and the observers on the macrolevel can be identical. This introduces an explicit notion of self-reference into the interpretation of observed phenomena. The result is that detailed behaviour of individuals who comprise a given social aggregate cannot be retraced in the observed collective behaviour of that same aggregate. This aspect has been discussed in detail by Thomas Schelling (1978), but much earlier already by Henri Lefebvre (1991) and Jean-Paul Sartre (1960) who term it „counter-finality". With a view to social systems of this kind, self-reference shows up in the fact that on the microlevel the „purposive" behaviour of persons is a relational concept in itself, because it depends on constraints determined by the environment which reduce its degrees of freedom eventually rendering it completely contingent. On the other hand, individuals depend on their essentially local knowledge produced by local interactions (on their microlevel) so that the global outcome is generically a result of superposition, not strictly independent of a single action taken, but in any case different from it. Institutional constraints (e.g. of legal sort), and feedback loops (of information) complicate the mediation of micro- and macrolevels and endow the process with an implicitly recursive characteristic. (Schelling 1978: 20f, 33, 50).

There is another point to this: We realize that social processes depend decisively on the concrete information flow. In this sense, a process (or phenomenon) can be said to be emergent, if at some time the architecture of information processing has changed such that a more powerful level of intrinsic computation has appeared which has not been present before. This criterion taken from Crutchfield (1994) can be shown to be essentially equivalent to the mediation criterion between microlanguage and macrolanguage given above. Visualized this way, innovation occurs at the threshold of information processing when the agent´s modelling capacity approaches the complexity of the same agent´s internal model.

(Crutchfield 1994: 25) This is so because (as we have seen above) the agent is always co-acting with others, and thus each model contains at least one self-model. At the same time, this has an important consequence for the relationship between order and disorder: because stability (order) is necessary for the consistent information storage while instability (disorder) is necessary for the production of information and its communication. Hence, it is the dialectic of stability and instability that is characterizing the modelling of evolutionary hierarchies of structure. And it is this trade-off that is relevant for computation theory. So if agents model their environment, their results depend on their capacity of identifying regularities (which explicitly takes place in terms of differentiating differences). This in turn depends on their computational resources and the language (model classes) utilized. Innovative emergence then, is the representation of attaining a new model class that improves the modelling process in the first place.

What we find therefore, is that the production of knowledge in terms of modelling the environment for the benefit of an adequate inference about observable processes can be visualized as an algorithmic form of computational process. This does not only mean that social processes are being modeled in terms of computational processes, but that in fact they are such processes. In other words: Information is physical. „Our world is the information process that is running in the computer, but this computer is not in our world.“ (Edward Fredkin) (Siegfried 2000: 58) In this sense, information shows up as the foundation of the reality we perceive. This computational process is algorithmic in the sense that for social systems, „purposive“ behaviour can be reflected by strategic choices of actions undertaken. For humans particularly, but not exclusively, the inventory of available algorithms is explicitly determined by the process of socialization. Hence, when talking about computation in this very fundamental sense, we are referred to a methodological framework that is concerned with problems of graph colouring, connectivity of networks, and so forth. Indeed, combinatorial optimization can be applied to such problems, despite the problem of irrational action, because information within this context can be roughly compared to „abstract pheromone“ as it is introduced in algorithmic studies of artificial ants colonies. (Dorigo/Stuetzle 2000, Stewart 2001).

Now, the topic of decentralization is important for all of this, because it is reflecting a basic organisational structure that governs both the phenomenological level of observations and the methodological level of modelling, respectively. In terms of the latter, this can be seen as a result of the intrinsic multiperspectivity of the models utilized. Hence, decentralization turns out to be a unified onto-epistemic concept rather than a mere pragmatic aspect (Resnick 2000). In terms of the former, decentralization shows up as a straightforward consequence of deriving global coordination from local interactions. As Crutchfield and Mitchell have discussed in detail, centralized organisation has three major drawbacks as compared to decentralized organisation: namely with respect to the speed of information processing (centres can be bottlenecks), robustness (central failure destroys system structure), and equitable resource allocation (centres draw resources) (Crutchfield/Mitchell 1994).

Crutchfield and Mitchell claim (and we agree) that evolution proceeds via a series of epochs that are connected to each other by distinct computational innovations. Hence, they can visualize the problem illustrated here as the evolutionary discovery of methods for emergent global computation in a spatially distributed system consisting of locally interacting processors. This is a useful viewpoint to be taken when talking about the simulation of such processes. And there are interesting results dealing with what they call „propagation of domain walls“ (or embedded particles). Note however that for the problem we have in mind here when referring to the emergence and evolution of urban structures, the concepts of space and time themselves have to be questioned. Because social structures, such as urban structures in particular, say, are not actually evolving within a given space: Instead, they produce their own space (Lefebvre 1991).

This aspect has been recently discussed in more detail (unfortunately, without referring to the pioneering work of Lefebvre) by Hillier and Hanson (1996, 1984). In order to model this primarily architectural space they develop what they call a „morphic language“ different from mathematical modelling in the strict sense, and from natural languages utilized in hermeneutics: In fact, while the latter strongly individuates primary morphic units within the framework of a comparatively permissive formal (syntactic) structure, the former utilizes very small lexicons and very large syntaxes which are virtually useless for representing the world as it appears. Hence, visualized this way, mathematical languages do not represent or mean anything except their own structure. The morphic language however utilizes a small lexicon and gives primacy of syntax over semantic representation. Hence, it is built up from a minimal initial system meaning its own structure (similar to mathematics), but it can be realized within experience and is subject to a rule-governed sort of creativity (similar to natural languages). (Hillier/Hanson 1984: 48-50). For describing the intelligibility of space, Hillier and Hanson explicitly utilize aspects of combinatorial topology when modelling spatial distributions of urban structures, often referring to (information) transport properties of graphs, connectivity, and percolation. This is actually the point from where we start our own approach utilizing a more generalized conception from the outset.

The idea is to eventually draw on the resources of category theory (or topos theory), because this is the field that comes closest to verbal conceptualization in the sense of Hillier´s and Hanson´s morphic language, without giving up the precise syntactic of mathematics. The point is mainly that categories provide both: the mathematical modelling of physically observable structures, and the logic conceptualization of this modelling, at the same time. This is the reason for starting here with relevant aspects of fundamental physics (in terms of recent results on quantum gravity). They may serve as a general framework for ultimately translating modelling procedures from physics to social science, avoiding the complete retreat into the domain of qualitative metaphors, but furnishing instead a semi-quantitative (morphic in this sense) approach which is resilient enough to remain relevant and sufficiently stable on the edge between logic and hermeneutic. However, it is not possible here to assemble all aspects of the theory utilized. This has been done in more detail elsewhere. (Cf. Zimmermann 1999, 2000a, b, c, d, 2001 for more explicit expositions). In particular, Zimmermann (2002c) gives a recent, not too technical survey of the general idea as derived from physics including detailed references. See Zimmermann/Soci/Colacchio (2001) for an introduction to the Bologna project where these aspects shall be put to empirical test. But what we will do here is to shortly summarize the basic ideas, discussing emergent computation as implicit in the concept of spin networks introduced by Roger Penrose (section 2), and referring to the underlying fundamental aspects of this approach as they are relevant for our topic here (section 3). We will soon notice that presently ongoing work in this field turns out to be not far removed from the line of approach taken here, although the methods applied may be diffferent in detail. But with a view to more recent expositions on complexity theory or population ecology such as Klomp/Green (1997) and Sharov (1996), and on spatial economy such as Krugman (1996) and Fujita/Krugman/Venables (1999), we can recover a lot of what will be said here under a more fundamental perspective. This is also true for a number of practical issues put forward in the political field (see Bahl 1999, Folkesson 2000, NCREL 2000, OEA 2001a, b). Also Stewart (2001) is very illustrative for economic issues. Similar aspects can also be found in Schweitzer (1998a, b, 2000) and Schweitzer/Zimmermann (2001). But first we start with the already mentioned point of visualizing space and time, the basic categories in which we perceive and reflect, themselves, as derived (hence produced) quantities that constitute our world as we perceive it.

2. Emergent Computation

The original idea of introducing a purely combinatorial (abstract) structure in order to eventually „derive“ space and time from it such that relativity and quantum theory show up as two different perspectives of the same underlying whole, goes back to Roger Penrose who invented spin networks. Basically, spin networks in this sense are trivalent graphs with a combinatorial loading called spin numbers. The idea is to represent abstract interactions between vertices: Be a, b, c natural numbers such that for any i, j, k the conditions i + j = a, i + k = b, j + k = c can be solved with non-negative integers. Then the edges of the graph can be visualized as expressing interactions of particles with spin a and b which produce a particle with spin c. Hence, for an unrestricted number of vertices and edges, we get a spin network consisting of vertices interacting by permanently exchanging spin numbers n such that n = 2s („measured" in terms of ħ). We could visualize therefore, the network as one that is generically fluctuating. Note however that no conception of space and time is entering the definition yet, so that we deal with a purely combinatorial process producing numbers as an output according to a given input. In this sense, we can think of this network fluctuation as of a computational process. In other words: There is a permanent processing of information that is underlying the structure of space and time on a fundamental level. If we take „large portions" of this network then, and choose two single strands of it, we can define the following relational structure: Take large portions K of the network, single out two smaller strands, N and M say, and compare their relative positions in terms of an isolated single strand (acting as a single edge) of spin number 1, then we can, according to the possibilities of re-combination, determine an appropriate angle between units which by superposition produces an angle in terms of Euklidean geometry. The total loading of a unit is given by what Penrose calls value of the network, essentially expressing a scalar product of spin network states. Be □ such a state, and □* its dual. Think of the portions of the network as being knotted by closing the strands to themselves. Then, in Dirac notation, we have for the value V of a spin network

<□□□> = V(□#□*)

with

V[...] = □ (1/j!) □ □(-2)^{N}.

Here, the product is being taken over all edges, and the sum over all vertices. Then, j is the respective edge label, N the number of closed loops, and □ the permutation rule for the signs being referred to as intertwining operation. The spin geometry theorem tells us then that the probability ratio of finding the network in consecutive states (by e.g. repeating the procedure of comparing isolated strands with respect to the „lump" network twice) is given by (1/2) cos □, with □ being a (Euklidean) angle. Hence, by a statistical choice of strands from the (lump) network, we can define an angle and thereby actually produce it out of a purely combinatorial structure due to a combinatorial process of selection. In this sense, the fundamentally underlying process of computation described here in preliminary terms as a permanent processing of information, is also a process of emergent computation such that from the underlying process classicity can eventually emerge and show up in terms of macroscopic physical structures.

The network structure can be made more explicit when projecting it onto a spherical surface. In fact, as it turns out, spin networks can be better visualized as a fundamental combinatorial level of space rather than of space-time as originally intended by Penrose. In this sense, Rovelli and Smolin have re-interpreted his ansatz somehow: They start with loops from the outset and show that since spin network states <S□ span the loop state space, it follows that any ket state □□> is uniquely determined by the values of the S-functionals on it, namely of the form □(S) := <S│□>. To be more precise, Rovelli and Smolin take embedded spin networks rather than the usual spin networks, i.e. they take the latter plus an immersion of its graph into a 3-manifold. Considering then, the equivalence classes of embedded oriented spin networks under diffeomorphisms, it can be shown that they are to be identified by the knotting properties of the embedded graph forming the network and by its colouring (which is the labelling of its links with positive integers referring to spin numbers). When generalizing this concept even further, a network design may be introduced as a conceptual approach towards pre-geometry based on the elementary concept of distinctions, as Louis Kauffman has shown. In particular, space-time can be visualized as being produced directly from the operator algebra of a distinction. If thinking of distinctions in terms of 1-0 (or yes-no) decisions, we have a direct link here to information theory, which has been discussed recently again with a view to holography.

The network which is the dual of the spin network is the appropriate triangulation of the spherical surface. This triangulation forms the dual 1-skeleton of the spin network. The length numbers attributed to triangle edges correspond to the spin numbers in the original network. Hence, they change accordingly. As the triangulation is the minimal covering of this surface, the length of a triangle edge gives a quantized portion of (3-) space. In other words, the quantum of a surface (area) and the quantum of a space (volume) can be derived directly from the network pattern. To be more precise, area A and volume V will turn out to be proportional to l_p^2 and l_p^3, respectively. So we can think of the „fundamental level" of physics (or rather of the boundary layer of this level) in terms of the fluctuating network structure corresponding at the same time to a triangulation that is the network´s dual. If one visualizes this structure as one which is fluctuating all the time, then one gets an animated impression of the fundamental level of physics which is easily comparable with a kind of permanent computational process underlying all what there actually is. This is roughly comparable to permanently ongoing communication on the microlevel of society.

Following a convention introduced by Baez, the permanent re-arrangement of spin numbers (and triangle edge lengths) is called spin foam. Note that visualized as a sequence, a spin foam can be thought of as a kind of temporal evolution of spin networks. However, the concept of time (and causality) is ill-defined on that fundamental level. A straightforward „quantization" of time (proportional to t_p) is not satisfactory so far, because it depends on the outcome of the question whether there is any time ordering on that level at all and whether therefore, time is an emergent concept (as is ultimately space). But if visualized as a sequence of spin network states, spin foams (thought of as constituting a kind of proto-space-time) turn out to be two-dimensional analogues of Feynman graphs: They are in fact 2-complexes with faces, edges, and vertices such that the amplitudes of faces and edges correspond to propagators and vertex amplitudes to interactions. A very useful model for spin foams is given by Barrett and Crane (developed 1998 until 2000) as a good candidate for illustrating the basic idea. The amplitude of a spin foam is given by the following product:

Z(F) = □ $_{f□□(2)}$ A(f) □ $_{e□□(3)}$ A(e) □ $_{v□□(4)}$ A(v),

where f, e, v are faces, edges, and vertices, respectively, and the □(n) are the n-simplices in the triangulation. The partition function is then

Z(M) = □$_F$ Z(F).

Now what is the „macroscopic" equivalent of the motion described here in terms of the „microscopic" level? Recall that according to the standard terminology, a loop in some space □, say, is a continuous map □ from the unit interval into □ such that □(0) = □(1). The set of all such maps will be denoted by □ □, the loop space of □. Given a loop element □, and a space A´ of connections, we can define a complex function on A´ x □ □, the socalled Wilson loop such that T_A(□) := (1/N) Tr_R P exp □$_□$ A. Here, the path-ordered exponential of the connection A□A´, along the loop □, is also known as the holonomy of A along □. The holonomy measures the change undergone by an internal vector when parallel transported along □. The trace is taken in the representation R of G (which is actually the Lie group of Yang-Mills theory), N being the dimensionality of this representation. The quantity measures therefore the curvature (or field strength) in a gauge-invariant way. Over a given loop □, the expectation value < T(□)> turns out to be equal to a knot invariant (the „Kauffman bracket") such that when applied to spin networks, the latter shows up as a deformation of Penrose´s value V(□). Hence, spin networks are deformed into quantum spin networks (which are essentially given by a family of deformations of the original networks of Penrose). There is also a simplicial aspect to this: Loop quantum gravity provides for a quantization of geometric entities such as area and volume. The main sequence of the spectrum of area e.g., shows up as A = 8□□ħG □$_i$(j_i(j_i + 1))$^{1/2}$, for c = 1, where the j´s are half-integers labelling the eigenvalues. (Compare this with the remark on space quantization above.) This quantization shows that the states of the spin network basis are eigenvalues of some area and volume operators. We can say that a spin network carries quanta of area along its edges, and quanta of volume at its vertices. A quantum space-time can be decomposed therefore, in a basis of states visualized as made up by quanta of volume that in turn are separated by quanta of area (at the intersections and on the links, respectively). Hence, we can visualize a spin network as sitting on the dual of a cellular de-composition of physical space. As far as the dynamics of spin networks is concerned, there is still another, more recent approach, which appears to be promising as to the further development of topological aspects of quantum gravity (referred to as TQFT).

We notice from what we said above that a spin foam is a two-dimensional complex built from vertices, edges, and polygonal faces, with the faces labelled by group representations, and the edges labelled by intertwining operators. If we take a generic slice of a spin foam, we get a spin network. Hence, a spin foam is essentially taking one spin network into another, of the form F: □ □ □´. Just as spin networks are designed to merge the concepts of quantum state and geometry of space, spin foams shall serve the merging of concepts of quantum history and geometry of space-time. Very much like Feynman diagrams do, also spin foams provide for evaluating information about the history of a transition of which the amplitude is being determined. Hence, if □ and □´ are spin networks with underlying graphs □and □´, then any spin foam F: □ □ □´ determines an operator from L^2(A$_□$ /G$_□$) to L^2(A$_{□´}$ /G$_{□´}$) denoted by O such that <□´, O □> = <□´, □´><□, □> for any states □, □´. The evolution operator Z(M) is a linear combination of these operators weighted by the amplitudes Z(O). This leads to a discrete version of a path integral. Hence, re-arrangement of spin numbers on the „combinatorial level" is equivalent to an evolution of states in terms of Hilbert spaces in the „quantum picture" and effectively changes the topology of space on the „cobordism level". This is the level we ultimately perceive when observing phenomena. In fact, change of form (Gestalt) can be visualized as a change of its underlying topology. Evolution (in macroscopic terms) can be understood therefore, as a kind of manifold morphogenesis in (emergent) time: Visualize the n(= 4, say)-dimensional manifold M (with ∂M = S □ S´ - disjointly) as M: S □ S´, that is as a process (or as time) passing from an (n-1)-dimensional space S to another (n-1)-dimensional space S´. (Here n-1 = 3.) This is the mentioned cobordism. Note that composition of cobordisms holds and is associative, but not commutative. The identity cobordism can be interpreted as describing a passage of time when topology stays constant. Visualized this way, TQFT might suggest that general relativity and quantum theory are not so different after all. In fact, the concepts of space and state turn out to be two aspects of a unified whole, likewise space-time and process. So what we have in the end, is a rough (and simplified) outline of the foundations of emergence, in the sense that we can localize the fine structure of emergence (the re-arrangements of spin numbers in purely combinatorial terms being visualized as a fundamental fluctuation) and its results on the „macroscopic“ scale (as a change of topology being visualized by physical observers). This is actually what we would expect of a proper theory of emergence. And this is also what we aim at in this present approach: The topological domain of the macroscopic scale will be discussed in terms of a suitable morphic language, if developed for discussing the emergence of social, e.g. urban structures. The underlying microscopic process structure that actually produces the macroscopic scale refers then to the actions taken by individual agents self-organizing into groups and institutions. In other words: What Hillier and Hanson call the intrinsic logic of an emergent spatial structure („space“ here in the sense of „social space“) is nothing but the operation of the selected algorithmic process representing the communicative ineractions on the microlevel of society. This operative procedure can be easily visualized as a process of emergent computation as motivated above.

Fundamental Information Processing

The important point is to notice here that from the beginning on, the concept of time is integrated into the geometrical representation from the outset. But it does not show up as a function, because the map that carries one space into the other is itself a manifold space. Hence, time is related to the frequency of topology changes encountered (by literally counting them). This is a notion of time that is very much on the line of the time concept introduced by Prigogine in the seventies. Essentially, time can be visualized as a measure for the structural change of the (spatial) world. These results can also be formulated in the language of category theory: As TQFT maps each manifold S representing space to a Hilbert space Z(S) and each cobordism $M: S \rightarrow S'$ representing space-time to an operator $Z(M): Z(S) \rightarrow Z(S')$ such that composition and identities are preserved, this means that TQFT is a functor $Z: nCob \rightarrow Hilb$. Note that the non-commutativity of operators in quantum theory corresponds to non-commutativity of composing cobordisms, and adjoint operation in quantum theory turning an operator $A: H \rightarrow H'$ into $A^*: H' \rightarrow H$ corresponds to the operation of reversing the roles of past and future in a cobordism $M: S \rightarrow S'$ obtaining $M^*: S' \rightarrow S$. So what we do realize after all is that spin networks, in particular as being visualized in terms of their quantum deformations, turn out in these models as the fundamental fabric of the world, in the sense that they are underlying and eventually actually producing the world of classical physics. Note in passing that this has an important philosophical consequence, because in being a functor and a theory at the same time, TQFT is constituted in an intrinsically onto-epistemic way: In other words, we model a physical structure in mathematical terms (with ontologically relevant results), and at the same time we model the modelling itself with respect to the specific logic which is underlying the category we are handling (with epistemologically relevant results. Hence, we do both: theoretical research and its conceptualizing.

The question is now as to the mediating concept that translates processes on the microlevel to processes on the macrolevel. This can be achieved by utilizing knot theory: We start for simplicity with crossings in non-orientied entanglements of strings. It is possible then to produce two diagrams out of a crossing by splitting it in two different ways. Labelling the various regions (produced by the first or the second version of splitting) by A and B, respectively, we find a whole family tree of possible splittings which end in a collection of Jordan curves called states of the diagram. Note that this tree structure exhibits clearly the relationship of form (Gestalt) and (underlying) dynamics: The „moves" necessary to resolve a knot and reduce the various crossings to states represent the implicit motion which is hidden underneath the morphological form of a knot. In other words, by performing prescribed (formal) moves one is actually reconstructing the motion that was necessary to form the knot in the first place. There is in fact a large class of possible (formalized) moves of this type, ranging from Reidemeister moves to Pachner moves (which turn out to be very significant with a view to the unfolding of spin networks, but on which we cannot comment here in this present paper). This relationship between actual „form" (morphology) and implicit motion (having eventually produced this form) resembles closely the relationship between implicit and explicit order as introduced a long time ago by David Bohm. It is also comparatively easy to demonstrate the algebraic relevance of crossings – illustrating the aspect of implicit motion under another perspective: Let a crossing represent the interaction of two curves, of a and b, say. We can interpret the result of this interaction as an abstract product ab which turns out to be non-associative. Hence, a close relationship can be easily demonstrated between the graphical representation of (knot) crossings and a non-associative algebra (of knots). In fact, as Kauffman can show in more detail, this approach leads to logical structures, if the crossings are orientied. We associate now a polynomial with a knot diagram in the following way: If □□□ is the number of loops in state □ (after disentangling all crossings of a knot) and <K□□> the product of all markings (labellings) in □, then the expression

$<K> = <K> (A,B,d) = \square_{\square} <K\square\square> d^{\square\square\square}$

gives a weighted sum over states and is called the bracket polynomial of the diagram K. We can also introduce a normalization condition in order to ensure ivariance of the polynomial under neighborhood isotopy. If so, then

$L_K := (- A^3)^{-\square(K)} <K>,$

where $\square(K) = \square_{p\square C(K)} \square(p)$ is the winding number (permuting signs). In order to compare this with more well-known aspects of combinatorial topology, we can think of the appropriate colouring of knots which leads to problems such as the colouring of neighboring regions or the street network problem („travelling salesman“ and its variants). Recall that in combinatorial topology, characteristic numbers (such as the winding number) of forms can be utilized to infer properties of the activity of suitable vector field actions defined on the respective forms.
Two more polynomials are of importance for our purpose here: One is the Jones polynomial, called $V_K(t)$, essentially a Laurent series in t associated to some oriented knot K such that

if K is neighborhood isotopic to K´, then $V_K(t) = V_{K'}(t)$,

$V(\ ) = 1$ (self-loop),

$t^{-1}V_X - t\, V_X = (\ t - (1/\ t))\, V$ (skein relations),

and such that in particular, $V_K(t) = L_K(t^{-1/4})$. Finally, we can also define the Kauffman polynomial Y_K which is given such that $Y_K = a^{-\square(K)} D_K$, and especially bears the relationship

$V_K(t) = [Y_K(t^{-1/4} - t^{1/4}, - t^{-3/4})]/(- t^{-1/2} - t^{1/2}).$

So what we have essentially done is to construct knot invariants by combinatorial means in analogy to partition functions. This can be read as a strict analogy, because the relevant expression of the form

$<K> = \square_{\square} <K\square\square> \square^{\square\square\square}$

describes an expectation value of the knot diagram, and the product on the right-hand-side expresses a product of weights. The knot diagram can be visualized then as an observable for a system of states. In the continuous version in terms of path integrals, this can be generalized by defining the same on a set of gauge fields with values in a given Lie algebra, such that

$$Z_K = \int dA\, e^L\, W_K,$$

where $W_K = \mathrm{Tr}\,[P \exp \oint_K A]$ is the trace of the path-ordered gauge exponential for the connection A. (This has been discussed first by Witten and Atiyah.) It can also be shown that spin networks can be retrieved by recalling that spinors of type ψ^A, A = 1,2 (complex), give rise to a group action of the form $U \in SL(2, C)$ which acts on a spinor such that

$$(U\psi)^A = \Sigma_B\, U^A{}_B\, \psi^A$$

with the conjugate spinor

$$\psi^*_A = \epsilon_{AB}\, \psi^B; \quad \epsilon_{AB} = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$$

so that the scalar product is defined by

$$\psi\psi^* = \psi^A\, \epsilon_{AB}\, \psi^B.$$

Hence, as to spin networks, we can visualize them alternatively, as simplices (and spin foams as complexes, respectively) that carry group representations on their edges and tensor products of them on their vertices.

We add the following two remarks: 1. The correspondance discussed before between spin networks and their dual 1-skeleta is reminiscent of the similar relationship between Voronoi diagrams and Delaunay triangulations. In fact, both of these pairs turn out to be equivalent. Indeed, by starting from a random distribution of points in a Voronoi fashion, it is likely that eventually classical space-time (or any other macroscopic geometry as to that) can be retrieved by means of „averaging“ over spin networks, once a fine tuning can be achieved in the relationship between their respective dual 1-skeleta (the triangulations). Hence, the topological structure of space (visualized in terms of „combinatorial topology“) can give hints as to the detailed structure of the spin foams actually underlying and thereby producing it. Similarly, on a classical and local basis, namely within chemistry e.g., the analysis of the relationship of Voronoi diagrams and their associated Delaunay triangulations can be also utilized in order to infer from the topological structure of a molecular compound to the underlying enzyme activities actually producing it. Some results have been achieved already with respect to base pairing in DNA visualized in terms of Grover´s quantum search algorithm by Patel. Earlier, Kauffman has discussed aspects of molecular folding utilizing knot theory. With the view to our attitude taken in the present paper, we would like to generalize this idea in discussing the correspondence between the macroscopic form of an urban structure as it can be described by an appropriate morphic language on the one hand, and the underlying microscopic processes actually producing it.

2. The other point concerns an idea of Lloyd´s who advocates the concept of visualizing the Universe altogether as a quantum computer arguing that by its mere presence, the Universe is permanently storing and processing information. In particular, he would like to understand as a chief result of this computation the emergence of decohering histories that by themselves evolve sufficiently complex structures. This aspect is very much on the line of our own argument. Hence, we can already recognize that knot structures turn out to establish an elegant and straightforward method to evaluate complex interactions. On the other hand, more to the point, and coming from the side of knot invariants as discussed above in the sense of (Lou) Kauffman, we can visualize the evaluation of the Jones polynomial as a generalized quantum amplitude, as Kauffman has shown recently: The braiding part of the polynomial coming from the polynomial´s skein relations as displayed above, can then be construed as a quantum computation. Hence, knot invariants show up as quantum computation. Kauffman utilizes the following concept of a quantum computation: It consists basically in the application of a unitary transformation U to an initial qunit (not a qubit with two entries, but now with n entries) □ with □□□^{2} = 1 plus an observation of U□. This will return the ket □a> say, with probability□U□□^{2}. If we start in □a>, then the probability that this arrangement will return □b> is in fact

□<b□U□a>□^{2}.

Then we introduce an operator formalism in Dirac notation:

□ (cup) = □a> : C □ V V (creation ket),

□ (cap) = <b□: V V □ C (annihilation bra),

<b□o□a> = <b□a> : C □ C (vacuum-vacuum amplitude).

Note that with Pr = □y><x□as projection operator, and Q:= Pr/ <x□y>, we have also QQ = Q. That is, the sum of projections is equal to the identity that relates to the completeness of intermediate states. In other words: The amplitude for going from a to b consists of the summations of contributions from all the paths connecting a with b. This is obviously consistent with the Feynman picture discussed earlier. Hence, what we have to do is to visualize the bracket model as a vacuum-vacuum amplitude. Then it can be configured as a composition of operators (cups, caps, braiding) – provided the braiding is unitary. This can be clearly viewed as a quantum computation: Choose the Cup as „preparation" part and the Cap as „detection" part of the computing, and call M the unitary braiding operator, then this can be summarized by the expression

$Z_K = \langle Cup|M|Cap \rangle$.

Hence, referring back from knots to their constituents, it is spin networks that can be thought of as representing the most fundamental channels of information transport: It is in fact quantum computation which is permanently being performed through the channels the spin networks provide. The latter serve as a kind of universal lattice through which the information produced by quantum computation is percolating such that an eventual threshold clustering in the sense of percolation theory spontaneously creates the onset of classicity. The actual route taken is that via the formation of knots in terms of spin networks and loops. That is, in the end, the classical world can be visualized equivalently as a „condensation" of knotted spin networks. More recently, a similar path (but with different conclusions) has been taken by Stuart Kauffman and Lee Smolin: They basically utilize a deterministic model of directed percolation to achieve similar results and show that this can be visualized as a cellular automaton. The idea is then to give the necessary criteria for a percolation phase transition which renders the system behaviour critical, which turns out to be essentially a derivation from Kauffman´s idea of a „fourth law" of thermodynamics: He basically asks whether we can find a sense in which a non-ergodic Universe expands its total dimensionality, or „total work space", in a sustainable way as fast as it can. He then refers to Smolin´s interpretation of spin networks and their knotted structures at Planck scale level as „comprising space itself". He suggests that knotted structures are combinatorial objects rather like molecules and symbol strings in grammar models, and he expects that such systems become „collectively autocatalytic" - practically showing up as knots acting on knots to create knots in rich coupled cycles not unlike a metabolism: „The connecting concept will be that those pathways into the adjacent possible along which the adjacent possible grows fastest will simultaneously be the most complex and most readily lead to quantum decoherence, and classicity. If complexity ´breeds´ classicity, then the Universe may follow a path that maximizes complexity." This is in fact his concept of a

„fourth law": that the adjacent possible will be attained which could account for the explicit „semantics" and dynamics of evolution.

There are two aspects in favour of these ideas: 1. the already mentioned case that classical geometry can be approximated by an average over all possible Voronoi configurations over a (n as yet) Riemannian manifold, as shown in the works of Luca Bombelli, and 2. the also mentioned case of the Barrett-Crane model for spin foams. As John Baez has formulated once in an e-mail discussion: „Now some people call a state in C^2 a ‚spinor', but other people call it a ‚qubit'. And what we are really doing, from the latter viewpoint, is writing down ‚quantum logic gates' which manipulate ‚qubits' in an SU(2)-invariant way – in fact, an SL(2,C)-invariant way! In short, we're seeing how to build little Lorentz-invariant quantum computers. From this crazy viewpoint, what the Barrett-Crane model does is to build a theory of quantum gravity out of these little Planck-scale quantum computers."

Conclusion

It should have become transparent after all what we are aiming at: The idea is to visualize the evolution of a macroscopically observable urban structure as the outcome of a superposition of social actions modelled in terms of a state function formalism (or decoherence) of all constitutive processes taking place on the microlevel of the respective social collective. The methods applied shall enable the inference from the observed topological structure to the underlying dynamics producing it. In other words: The social logic of space shall be retrieved by re-constructing the fundamental motion on which it is actually being based. Process governs structure in this sense, not viceversa, as has been assumed for a long time. The relation between process and structure resembles therefore the celebrated relation between micromotives and macrobehaviour in the sense of Thomas Schelling. As to decentralization being visualized as an organizing principle for urban structures in particular, we notice that this specific evolutionary mode is implemented into the systematics of the approach from the outset, because it turns out as a straightforward consequence of the mediation structure between micro and macro, in the first place. With a view to the actual research undertaken with respect to the evolution and structure of the historical centre of Bologna, the idea is to compare the specific logic of space in that case with the former political concept of decentralization as it has been operated by the city administration for a long while in the past. Further work is forthcoming.

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References:

Bahl, R. (1999) Implementation Rules for Fiscal Decentralization. Georgia State University, Atlanta GA. School of Policy Studies.

Crutchfield, J.P. (1994) The Calculi of Emergence. Computation, Dynamics, and Induction. Working paper SFI 94-03-016. In: Physics D 1994 Special Issue (Proc. Oji International Seminar on Complex Systems, 1993).

Crutchfield, J.P./Mitchell, M. (1994): The Evolution of Emergent Computation, SFI Technical Report 94-03-012.

Dorigo, M., T.Stuetzle (2000) The Ant Colony Optimization Metaheuristic: Algorithms, Applications, and Advances. TU Darmstadt. Preprint.

Edmonds, B. (1999) Syntactic Measures of Complexity. Thesis (Phil. Dept., University of Manchester).

Folkesson, R. (2000) European Support to Democratic Decentralization and Municipal Development, Keynote Presentation, Maastricht.

Fujita, M., P.Krugman, A.J.Venables (1999) The Spatial Economy. Cities, Regions, and International Trade. Cambridge (Mass.), London. MIT Press.

Hillier, B. (1996) Space is the machine. A configurational theory of architecture. Cambridge University Press.

Hillier, B./Hanson, J. (1984) The Social Logic of Space. Cambridge University Press.

Klomp, N.I./Green, D.G. (1997) Complexity and Connectivity in Ecosystems. www.csu.edu.au/ci/vol03/klomp/klomp.html.

Krugman, P. (1996) The Self-Organizing Economy. Oxford. Blackwell.

Lefebvre, H. (1991) The Production of Space. Oxford. Blackwell. (Anthropos, Paris, 1974, 1984).

NCREL (1993) Policy Briefs [on Decentralization], www.ncrel.org/sdvs/areas/issues/envrnmnt/go/.

OEA (2001a) Reunión de Ministros y Autoridades de Alto Nivel Responsables de las Políticas de Descentralización etc. La Paz.

OEA (2001b) Building Democracy from the Grassroots. Washington DC. Aide-mémoire. www.upd.oas.org/Decentralization/.

Resnick, M. (2000) Turtles, Termites, and Traffic Jams. Cambridge (Mass.), London (1997). MIT Press.

Sartre, J.-P. (1960) Critique de la raison dialectique. Paris. Gallimard.

Schelling, T.C. (1978) Micromotives and Macrobehavior. New York/London. Norton.

Schweitzer, F. (1998a) Selbstorganisation in der urbanen Strukturbildung. In: Nichtlineare Dynamik (Workshop des SFB 185, Riezlern 1997, Frankfurt[a.M.]/Marburg 1998). pp. 38-48.

Schweitzer, F. (1998b) Ökonomische Geographie: Raeumliche Selbstorganisation in der Standortverteilung. In: Schweitzer, F./Silverberg, G. (Eds.) Evolution und Selbstorganisation in der Ökonomie (Selbstorganisation. Jahrbuch für Komplexitaet etc., Vol. 9). Berlin. Duncker & Humblot. pp. 97-125.

Schweitzer, F. (2000) Emergenz und Interaktion. In: Th.Waegenbaur (Ed.) Blinde Emergenz? Heidelberg. Synchron. pp. 49-64.

Schweitzer, F./Zimmermann, J. (2001) Communication and Self-Organisation in Complex Systems: A Basic Approach. In: Fischer, M. M ./Froehlich, J. (Eds.) Knowledge, Complexity, and Innovation Systems. Berlin. Springer. pp. 275-296.

Sharov, A. (1996) Quantitative Population Ecology. Online Lectures. Entomology Dept. Virginia Tech, Blacksburg VA. www.gypsymoth.ento.vt.edu/~sharov.

Siegfried, T. (2000) The Bit and the Pendulum. New York etc. Wiley.

Stewart, M. (2001) The Coevolving Organisation. Online Text. Decomplexity, 2001.

Stuetzle, T., H.H.Hoos (1999) Ameisenalgorithmen zur Loesung kombinatorischer Optimierungsprobleme. TU Darmstadt. Preprint.

Zimmermann, R.E. (1999) The Klymene Principle. Kasseler Philosophische Schriften, IAG Philosophische Grundlagenprobleme.

Zimmermann, R.E. (2000a) Loops and Knots as Topoi of Substance. Spinoza Revisited. www.arXiv.org/pdf/gr-qc/0004077 v2. (Also in Zimmermann 2002d)

Zimmermann, R.E. (2000b) Classicity from Entangled Ensemble States of Knotted Spin Networks. A Conceptual Approach. Icmp2000. Imperial College London, www.arXiv.org/pdf/gr-qc/0007024 . (Also in Zimmermann 2002d)

Zimmermann, R.E. (2001) Basic Aspects of Negator Algebra in SOC, www.arXiv.org/pdf/nlin.AO/0105065 . (Also in Zimmermann 2002d)

Zimmermann, R.E. (2002a) Signaturen. NaturZeichen & DenkZettel. Zur morphischen Sprache der politischen Oekonomie. (As an appendix in Zimmermann 2002d)

Zimmermann, R.E. (2002b) Spin Networks as Channels of Information Processing. In: Preparatory Conferences, Research Project: General Theory of Information Transfer and Combinatorics, Zentrum fuer interdisziplinaere Forschung (ZiF), Bielefeld. (Invited Contribution.) www.arXiv.org, to be put (cs).

Zimmermann, R.E. (2002c) Graphismus & Repraesentation. Zu einer poetischen Logik von Raum und Zeit. Journal of Communication, Design, and Society, No.2 (Muenchen). Im Druck.

Zimmermann, R.E. (2002d) The Physics of Logic. Collected Archive Papers 2000-2001, containing two joint papers and one paper in German. Kasseler

Philosophische Schriften, Materialien und Preprints, IAG Philosophische Grundlagenprobleme.

Zimmermann, R.E./Völcker, W. (2001) Topoi of Emergence, www.arXiv.org/pdf/nlin.AO/0105064 . (Also in Zimmermann 2002d)

Zimmermann, R.E./Soci, A./Colacchio, G. (2001) Re-constructing Bologna. The City as an Emergent Computational System. An Interdisciplinary Study in the Complexity of Urban Structures. Part I: Basic Idea & Fundamental Concepts. In: www.arXiv.org/pdf/nlin.AO/0109025 v2. (Also in Zimmermann 2002d)

An Integrated Notion of ”Law“

Annette Schlemm

1. Introduction

If we speak about laws of nature and society we are in a confused situation. On the one hand we speak about scientific propositions with a special structure, called ”laws of science“ – and on the other hand we speak about the world to which the propositions refer. We see more or less essential relations in the world – and we describe them with language and mathematics. There are many ways to describe them – but there is only one world. Sometimes this world looks like it is determined (maybe by connections, which we can call “laws”), sometimes it looks like it is undetermined. What is the applicable view? It depends...

We often disregard the hierarchical structure of our world when we talk about determinism or indeterminism. Hierarchical structure means that all things are composed of parts and that they are parts of other, larger things. That does not mean, that the „greater“ thing must reign over the others – its only a structural reality. Because we are aware of the association of all things in the world we have to consider that there are differences in the world, too. There are differences at each level – and there are different levels of structures, from elementary particles across atoms and bodies to cells, organism and social structures. If we ask what is determined or not fully determined, we have to consider the nature of our system, its elements, and its environment. I think, necessity and chance are objective-real categories – in their relativity to the ontological system or element. But in our view categories´ necessity and chance are dependent on what system and elements we assume (see the principle of observability in the papers of Budanov/Savicheva and Arshinov/Budanov about principles of synergetic; Budanov/Savicheva 2002, Arshinov/Budanov 2002).

2. What are Laws in General?

We don´t speak about laws in the legal sense here, although the concept of laws in nature and society was derived from laws in jurisprudence. Here I´m interested in understanding the nature of laws in the natural and social sciences and their correspondence to nature and society. I don´t follow analytical philosophy that assumes that laws are merely statements about everything in a given topic. There is no clear notion of a law. I think the only common ground is that laws deal with some general and universal characteristics. Hempel said that laws must have a general form because of their function in scientific explanations (Hempel 1965: 343). But not all general or universal statements are (expressions of) laws (Ayer

1976: 192). Popper uses the term “natural necessity” to distinguish between mere generalization of facts and generalization of laws (Popper 1989: 382). But Ayer (1976: 192) rejects this, because he thinks that the determination of necessity uses the notion of lawfulness and this would be circular. Popper derived the natural necessity from other considerations.

Röseberg called laws “universal-necessary connections” and declared that “universal-necessary” means that the connections are due to a certain class of objects with necessity. (Röseberg 1975: 9). The behaviour of such objects will show that under the same essential conditions the same event will occur. Hörz emphasizes this reproducibility (Hörz 2001).
It is not usual, but helpful, to understand laws as universal-necessary and/or “essential connections”. Modern philosophers of science mostly refuse such “metaphysical” terms like “essence”. But a dialectical approach can understand it in a useful way. The simplest understanding of essentiality of laws is: The essence determines the characteristics of the connection, which determine the difference to other systems (Röseberg 1975: 9). The determinations of “system”, “essence” and “law” are connected in a dialectic way.

3. The Synchronous View

3.1. About Dynamical and Statistical Laws

Max Planck distinguished dynamical and statistical laws. Dynamical laws unequivocally connect present states with states in future. Statistical laws connect them only by probability. In classical mechanics the physical states are usually connected in a dynamical way. This view presupposes a classical view of motion. In this view we assume, that all quantities of motion can be exactly measured and the calculated trajectory corresponds to the real path of the body. We can assume the second Newtonian law [$d/dt\ (mv) = F$] as a dynamical law: The equation describes an infinite set of possible trajectories. If we add specific initial conditions to this we´ll get one possible trajectory for the bodies, which will be realized exactly. Chances are only sources of irritation.

Laws in their dynamical form can be defined the following way. A law is a „universal-necessary connection, in the sense that there is, depending on the initial conditions, only one possibility which necessarily realises itself “ (Hörz 1974: 465). This form of a law contains the possibility of behaviour at *one* level of structures and not the connections between such levels. If there are influences from other levels, they are seen as mere contingencies.

But if the influence of these contingencies becomes greater and greater – the behaviour of the body seems to be unlawful, indeterminate.

In thermodynamics and quantum theory we have to use statistical laws. It´s interesting that Max Born showed that classical mechanics can be written as a theory using only statistical laws too (Born 1961/1963: 461f.). Schrödinger quoted Exner, who assumed that "it is possible that the laws of nature have a statistical character " (Schrödinger 1922: 16). With respect to Darwin and Boltzmann Schrödinger wrote: "It involved a new outlook on the nature of the laws of Nature; namely, that they are not rigorous laws at all, but "only" statistical regularities, based on the law of great numbers" (Schrödinger 1944/1984).

3.2 An Integrated Notion of Law

3.2.1 Integrated Notion of Law for a System and its Elements

These two approaches, the dynamical and the statistical, are different but not unrelated. We don´t have to decide between them. The form of laws depends on the form of motion. We know dynamical and statistical motions and dynamical and statistical forms of laws. Is there mere an inseparable difference between dynamical and statistical forms? Sometimes, if we can presuppose the dynamic view of motion (we can see only the motion at one level and take the influences from other levels as unessential chances), then we can use the dynamical view of law (like Newtonian Laws and Lagrange- and Hamiltonian equations) or the statistical (like Max Born did). We have learned that in thermodynamics and quantum theory we can´t presuppose the dynamic view of motion; the phenomena of the macroscopic level are not separable from the „lower" level and therefore here we have to consider the essential connections between the macro- and the microlevel and we must use another form of laws.

In the 1970s Herbert Hörz integrated the two views into one notion of law. He called it the "statistical notion of law", because the statistical view can include the dynamical view. But I suggest using the term „integrated notion of law" in order to avoid a confusion with the "pure" statistical notion of law and in order to interpret other forms of lawfulness (see below) like the "singular particular". For that integration we suppose, that there is a system that is built from elements. Each element can be a system itself and each system may be an element in a „higher" system. But if we speak about laws of a special system, we hold one system and its elements in our glance. This view we call the "synchronous view" (later we will discuss the diachronic view).

Now we can say: At the level of the system we focus our glance on the self-identity (and self-reproduction) of the system itself. If it would have another form of existence or self-reproduction, it would be another system. Therefore the system at this level has only *one* (essential) possibility for existence, self-reproduction and motion (the unessential characteristics may change). If a thing has more than one essential possibility, it is built of several systems. (Now we have a definition of such a system: it is an entity, which has at this level of structure one possibility of behaviour only). For the system as a whole we get a dynamical lawful behaviour – it will move according to a determined tendency. For example, a classical mechanical law contains a set of *all* possible paths. The determined tendency of the system as a whole shows us the „dynamical aspect“ of the Integrated Law.

At the level of the elements there is a degree of “freedom”. Elements are not only ”smaller things“ – we assume measurements, trajectories, or other phenomena to be the elements of a system in physics. These elements are not fully determined by the dynamics of the system. They have a set of possible behaviour, statistical behaviours (with respect to the system – if we regard them as systems themselves they will have dynamical behaviour too). There is a ”distribution of probabilities“ for the behaviour of the elements. We get probabilities to measure special quantities. Only in trivial cases we will get a probability of 0 or 1. This aspect is called the ”stochastic aspect“ of Integrated Law.

Now we look at a single phenomenon. For each phenomenon there is a probability of transition from one state to another. This is called the ”probabilistic aspect“ (for a discussion of some details cf. Schlemm 1996: 213 ff.).

The unity of all aspects can give us an integrated notion of law: A law is a „universal-necessary connection, which determines one possibility for the behaviour of the system, which will realize necessarily (dynamic aspect), in which exists an objective field of possibilities for the behaviour of the elements, from which one possibility will be realized by chance (stochastic aspect) and this possibility has a certain probability (probabilistic aspect). (Hörz 1974: 365/366)

The connection of two neighbouring levels at least is very relevant for all approaches of worldview. The German physicist and philosopher Ulrich Röseberg wrote: “The philosophical interest of attempts to establish the statistical physics is grounded on this, i.e. that in this theory the connection between two objectively separated material levels of structure (atoms, molecules and macro objects) is given in a particular science which is important with respect to analogous questions for more complex systems (living beings, societies).“ (Röseberg 1975: 107).

3.2.2 Necessity and Chance in the Integrated Notion of Law

There is a unity of the necessary tendency of the system and the accidental behaviour of the elements (in relation to this system) in an integrated law. We are not allowed to forget that system and elements are relative: Systems may be elements in other relations and elements can be systems too. Necessity and chance are relative to being a system or an element.

Because it depends on our point of view, we can think that there is no real difference. But in reality there is: There are really connections that determine a dynamic tendency for a unity at one level (the system) and behaviour by chance for its elements. For each system there exists a totality of conditions. This totality of conditions (for the system it is only given in an analytical view, never in reality) determines the necessity of the behaviour of the system. Seen from this level, the behaviour of the elements is only determined by *partial* wholeness of conditions, i.e. the behaviour is determined/conditioned by chance.

The connection of system- and element behaviour is given by the constitution of the possibility of the system by the behaviour of the elements. And at the same time the possible behaviours of the elements is not fully but partially determined by the system. Ernst Bloch said: “Even the vacant is not arbitrary... the can-be is lawful, too.“ (Bloch: 172)

3.2.3 The Integrated Law in Physics

3.2.3.1 The Dynamical View of Newtonian Mechanics

The system in Newtonian mechanics will be a set of measurements (maybe of planets) – the measurements are the elements of the system. We are presupposing that the body will at each time be at one certain location and that these points can be measured with any required exactness. Then and only then we can reduce the integrated law to its dynamical aspect because we have now eliminated all accidents in the behaviour of the elements (measurements).
We´ll get our ”reduced“ integrated law in the form:

In classical mechanics we are not interested in the inner structure of the moving body. And its motion is characterized by unambiguous trajectories whose diversity can be calculated with equations and conditions. We´ll get a single path, if we use concrete initial conditions, which are not determined in the law. The law contains an infinitive set of paths (of mathematical possible paths) and the conditions will select the (one) real possible path. This real possible path is the ”necessarily realizing“ mathematical possibility (even if the behaviour is not computable).

Dynamic aspect	Stochastic aspect	Probabilistic aspect
We can determine the behaviour of a mechanically moving body in an unambiguous way with given initial conditions, mass and influencing forces.	The set of possibilities is reduced to one determined unambiguous measurement.	Each measurement will give us the same result (with a probability of 1).

Classical mechanics as a prototype of science

Classical mechanics with its reduction of the dynamic aspect became the prototype of science.
But what premises do we have to take into account? Its method is grounded in the elimination of dialectical contradictions. The real dialectical contradictions (i.e. the contradiction of movement, like Zeno showed us) are reduced in this way: We determine such quantities, in which the opposite moments are distributed. We don´t use the place of a moving body at one time and the place at another time, because there is the Zenonian contradiction of movement. We use the place and the first derivative of a space-coordinate (velocity) in our equations as quantities. Now non-contradictionary mathematics is possible (see Ruben 1977: 115).

We distribute the whole process in an analytical way and we get two forms of the process:
The process of maintaining the identity of the state of motion of the body (self-maintaining-first law of Newton), and the changing of the state of motion as a result of forces from outside (second law of Newton).

Dynamics deals with ”searching these determining factors, which are an expression of the maintenance of the system within the interactions of its elements“ (Ruben 1977: 115). This shows: If we reduce the integrated law to the dynamical aspect, we´ll be focused on the aspect of self-maintenance. We can see only the way determined with tendency of the whole system.

3.2.3.2 The Statistical View of Newtonian Mechanics

Max Born showed that classical mechanics can be interpreted in a statistical way. He takes statistical distributions for the initial values and the quantities become probabilities, not exact coordinates. In the dynamical view we took the disturbing influences as unspecific. Now these influences will become specific conditions of the effect. The state is not determined by exact coordinates, but by a probability distribution. We will get single measuring-quantities from a series of measurements (of one state).
Now we´ll get our integrated law in the following form:

Dynamic Aspect	Stochastic Aspect	Probabilistic Aspect
There is one possibility, which is realized necessarily, for the distribution of probabilities.	There is a set of possibilities for the separated measured quantities. In each single measuring one of the possibilities will be encountered by (partially conditioned) chance.	Each of these quantities has a certain probability.

3.2.3.4 Statistical Physics

Statistical thermodynamics connects two levels of structure. The macroscopic motion of particles is considered as a result of the motion of the molecules at the micro level. The macroscopic area is characterized by physical quantities like temperature and entropy. These are functions or functionals of microscopic quantities (i.e. velocities of particles). The function of distribution is the necessary realizing possibility of the system. The microscopic quantities fluctuate. Fluctuations become immediately constituting elements of theory. "Fluctuations belong to the essential characteristics of the macro physical state (necessity asserts itself through individual fluctuations – therefore by chance – "law of fluctuation")" (Röseberg 1975: 120).

Here the elements really are the objects of a deeper level (not only measurements or something similar). Here the wholeness is a "sum of relatively isolated separated objects which are interacting, but the interaction has accidental character" (Hörz 1964: 164). This is a difference from quantum theory.

Now we can consider the integrated law for statistical thermodynamics:

Dynamic aspect	Stochastic aspect	Probabilistic aspect
Distribution-function (for velocities of particles) is the necessary realizing possibility for the system.	The set of possibilities contains the individual fluctuations of velocity.	Each particle has a concrete velocity and for this velocity there is a probability.

3.2.3.5 Microworld

Quantum mechanics

In quantum mechanics we can´t assume isolated ”smallest bodies“, which can be found at a certain time at a certain space. The classical-mechanics-motion-view fails. Even in classical mechanics we don´t speak about bodies in reality – we speak about their ”mass points“ and idealized paths (because the classical view of motion is an idealization). Now we use other idealizations and constructions. We speak about operators in a Hilbert space and construct new measuring-quantities, called observables. These observables can´t all be measured simultaneously. The objects of quantum mechanics are states which are superpositions of eigenstates.

Before measuring we have only information about the discrete spectrum of eigenvalues of observables, i.e. a statistical proposition as information about the state. (The statistics belongs to repeated measurements, not an ensemble of particles!). If we measure, then we act in a materialistic way with our technical devices. The quantum-objects and the device become one system, they are no longer independent from each other. The wave function is not a product of the wave function of the object and the wave function of the device (Meier/Zimdahl 1986). Now a projection happens into *one* eigenstate which is determined only statistically and we can´t know it before measuring. This is often called ”reduction of the wave-function“ – but we can get more precise information now. In our measurement we have interrupted the whole quantum process, we have neglected certain aspects of motion (Hörz 1964: 135).

The possibility for the behaviour of the system is given by the motion-equation (Schrödinger-equation) for the state-vector and the possibilities which are realizing by chance are the wholeness of simultaneous measurable observables, whose expectation-values can be determined. Now for quantum mechanics we have: the theory records possibilities of behaviour of the quantum objects and one of them will be realized conditioned by concrete conditions of experiment.

Dynamic aspect	Stochastic aspect	Probabilistic aspect
The possibility of behaviour of the system is given by the equation for in the Hilbert-space.	The field of possibilities contains the discrete spectrum of eigenvalues of the observables. This field/set refers to repeated measurements, not an ensemble of particles. Even after a measurement the object and the measurement instrument will stay correlated, we don´t know an exact measuring value.	There is a projection to one eigenstate in each single measuring – called ”reduction of the wave-function“. This is *not* included in the Schrödinger equation. The projection is caused by interuption of the movement, by neglecting of certain aspects of movement (Hörz 1964: 135)

The state can change in two ways. It can change continuously, if we consider an isolated system without interaction or measuring according to Schrödinger´s equation. But if we take into consideration the interaction of a non-isolated system, we get a discontinuous change, according to probability laws.

The Copenhagen interpretation concentrates on the interaction between quantum object and measurement system. It was shown by Bohr that we can speak about a “phenomenon” only if we look at the whole process with its conclusion: the registration (“irreversible amplification effect”) (Bohr 1958/1985: 96). Therefore in quantum mechanics all knowledge about quantum objects contains the interaction of quantum objects and classical objects, of objects and the practice of subjects. This brings the statistical character into quantum mechanics. Grete Hermann showed that such a statistical view doesn´t deny causality (Hermann 1935: 721). Quantum Mechanics expects a lawful explanation also for events, which are not predictable in advance.

The new decoherence-interpretation, based on Zeh (1970), assumes that there has to be a dynamical cause for the non-occurence of observed superpositions in macro-world. Zeh analysed the dynamical decoupling of components following Everett (1957/1983). For macroscopically different states he recognised that “the significantly different interaction of their components with their environment” (Zeh 1970: 348) destroys their superpositions.

Decoherence describes the fleeting interactions between an object and its environment, which allow the object to select a concrete state from a lot of simultaneous possibilities (Hergett: 6). By means of this decoherence we can calculate that systems with a big mass and chaotic systems have a very short coherence-time and from this coherence-time one can derive that the classical world has no quantum behaviour. The decisive innovation of the decoherence-conception is the consideration of the influence of the environment and the consideration of the object and the measuring instrument as open systems (see Müller 2003).

Dynamic aspect	**Stochastic aspect**	**Probabilistic aspect**
Correlation of object, measuring instrument and environment. Description by a mixed density matrix.	Environment-induced decoherence destroys the coherent superposition. All possible results of measuring are elements of the reduced density matrix.	Transition to one measure-value (not described yet - see Müller: 6).

I think this view corresponds to the assumption of Wheeler, who said that "each of the laws of physics [is] at bottom statistical in character" (Wheeler 1980/1983: 203).

We see that a view that assumes that the quantum-objects are separable "things", fails (only some properties are stable like mass, charge, spin). There are always interactions. Quantum theory shows that only if we consider the openness of real (quantum-)systems, we can explain the stochastic and probabilistic aspect. If we look at "deeper" levels, some of the "stable" properties will demonstrate their instable character too.

Elementary Particles

In quantum mechanics we speak about states like |□ > in a Hilbert space, not about "little objects". When we speak about "little objects in the micro world" we mostly speak about elementary particles. Modern physics tells us that these particles seem to have no intrinsic characteristics – only interactions give them their characteristics. Without concrete interactions – in a symmetric state – electrons and neutrinos would have no differences, they would be the same thing. Only the interaction with (not yet observed) Higgs-particles gives the electrons their mass – Higgs-particles for a neutrino-mass don´t exist in our concrete world (Smolin 2002: 67). In such a way differences emerge through concrete interactions in the world. This is called symmetry-breaking. "Each elementary particle possesses a set of several potential characteristics, but only one is realised in a stable universe" (Smolin 2002: 69). The theory (the dynamic aspect of law) is symmetric, it can´t determine the concrete stable configuration. Only the concrete system "will decide". We can say now:

Dynamic aspect	Stochastic aspect	Probabilistic aspect
In the theory of elementary particles (i.e. Weinberg-Salam-model) there is a unity of particles (without concrete interactions or before concrete conditions emerged in the very early cosmos).	In this unity there are many possibilities to become particles (or interactions) with several different characteristics.	When symmetry-breaking happens the particles get certain characteristics.

Theories of Everything?

There is yet no successful "Theory of Everything" – a theory of the foundation of the world, of the final unification of the fundamental forces in the world. For a long time many scientists trusted in the string- or superstring-theory. But in this theory there are 9 dimensions, which is 6 dimensions too many. It is possible to explain these extra dimensions as rolled up, and thus not detectable. But there are many, many possibilities to roll them up and these possibilities produce too many new parameters (Smolin 2002: 83). The conclusion of such a Theory of Everything would be: "Everything is unified, but there are ten thousands of possibilities for the configuration of the universe." (p. 88).

Based on Roger Penrose´s suggestion to view physical laws as combinatory principles, some physicists have developed another fundamental theory, the loop-theory. Each quantum state can be considered as loops of space – or better: spin networks. The most amazing characteristic of such spin networks is that also space and time turned out to be only a possibility of being of the network of relations (Smolin 2002: 36, Smolin 1995 and Zimmermann 1991).

3.3 The Integrated Law

The Integrated Law combines the necessity of whole systems (the motion of the system tends to be determined with necessity) and the conditional-probable behaviour of the elements of the system, and in this way, the system with its outer conditions (which influence the symmetry-breaking). Because each system is an element in a "comprising" system and each element is a system itself (hierarchical structure), we get a concept in which necessity and conditional-chance are connected. The elements are not fully determined by the system. The law has a necessary tendency – but its elements have a “field of possibilities”, which depends on really given (and changing) conditions. Each thing is a system and an element likewise. Furthermore the law has an inner structure. This structure is the prerequisite for the occurrence of symmetry breaking in temporal changes. Then the influence of the outer conditions can no longer be neglected.

This concept is an approximation to a *concept of possibilities in a lawful world*. It works in the sphere of abstract system-thinking and uses the dialectic “essence” to determine which connections are laws (unessential connections are not laws, see above). It is not concrete enough to determine the particular characteristics of the elements. There is a tendency to assume that the elements are homogeneous, and to ignore the essence of human being: individuality, the special quality of each individual. When referring to human society, we have to add that humans are equal only in the sense that each individual has its own special quality. Here the abstract notion of law cannot grasp the special concrete (!) quality of human being.

4. The Diachronic View

In the diachronic view we are interested in the temporal development of the behaviour of systems and elements, not only their structure. We have to consider two possibilities:
a) The elements are smaller objects like molecules, atoms, cells or so on for the whole system.
b) The elements are qualitative determined moments, factors or so on and not only ”smaller things“. Systems and their elements are not eternal phenomena, they change in time. And they are changing in several specific ways. There is not only chaotic change in the world: for a while we can regard a system as relatively stable (see 4.1) and in other times there are (more or less) important changes (see 4.2).

4.1 Stable Self-reproduction

If we speak about systems, we mostly speak about their identical self-reproduction. In this relatively stable phase, a complex system maintains its identity by self-reproduction of its elements. We can say that a living being maintains itself by changing its biochemical processes and renewing its parts. With respect to a) we can see that a society may be stable although its members are born, live and die. And with respect to b) we can say that e.g. the economic process reproduces itself by changing its interacting moments: production, consumption, distribution and exchange.

Now we have the situation of the synchronic view seen as a circular process: The elements build up the system and the system constraints the possibilities of the elements to do that.

The Role of Fluctuations of Elements

There are fluctuations on the level of the elements at all times. These fluctuations are suppressed (physical solid bodies) in some systems, other systems consist of regular fluctuations (thermodynamic macroscopic quantities). In society there is another ”degree of freedom” for the individuals: They don´t have the function of constituting society – society exists to enable the individuals´ human freedom! (cf. the specific connection of possibilities for human beings in the Critical Psychology of Klaus Holzkamp).

Maybe in stable phases of development of the system there are other forms of elements (emerging by fluctuations) that are not the main quality of them. But they are not important, not specific, not essential for the system and therefore they will be suppressed. But the system will come into a phase, in which the fluctuations, i.e. the other possible qualities, will become important. Systems come to such a phase, because their self-maintaining-processes exhaust their own conditions (Schlemm 1996). In our further explanations we will speak about complex systems with a non-linear behaviour and an entropy-export.

If the system reaches a point in which it can´t proceed further in its previous way, then new possibilities will emerge. Some of the fluctuations of the previous set of possibilities for the elements can become essential. And a new field of possibilities emerges as well....
It is typical for all complex systems to reach a „critical point“ in this phase. A new way to exist must emerge in this point – but it is not determined by the previous process: a specific new quality comes into being. Because the path of development has more than one possibility we speak about ”bifurcation“ and the ”bifurcation-point“. Such a form of development is essential to the conception of self-organisation.

4.2 Emergence of Novelty in the Bifurcation Points

In the approaches to self-organisation the probabilistic aspect becomes very important. Here, changes of qualitative states are the topic of science. We sometimes speak about a paradigm-shift from the classical, dynamical view to the new self-organisation-view. We know the metaphors about symmetry-breaking, about ”sensible phases“ and so on. Chance is here the ”constituting moment of the building of structures“ (Hörz 1990: 37).

Uwe Niedersen even suggests considering that ”singular individuals“ transcend the ”fixed fields of possibilities“(Niedersen 1990: 79, see also Niedersen 1988). Yuriy Myelkov (2002: .3) suggests assuming spontaneity as the correct term for a “third kind” of determination. We mentioned that the fields of possibilities will change at bifurcation-points, too. We have to take into account that there are not only “old possibilities” of the “old system”. The old system can vanish – a new system can emerge, a system with it´s own new possibilities. But the old and the new system are not unconnected. They are connected by (spatially and/or temporally) larger connections. We get – in a like manner we got a hierarchy of systems – a hierarchy of laws. There are transitions: In our synchronous view we get transitions between several levels of structure and in the diachronic view we get transition between temporally states of systems.

The Hegelian view emphasises the dialectical transitions in a form like steps between the states – without a possibility of ramifying. This view works, when we ask how a given stage emerged from its predecessors (if we look from present time to the past). But if we are standing in our present time and are looking forward into future, we can´t use this view only. Now we use the knowledge about the openness of future, the different possibilities, what can happen, the possibility of ramifying similar bifurcations (later we will see a step-like way with a backward view, too).

In a transition between stages or states with essential qualitative differences we will transcend the range of a law. Because there is a hierarchy of systems (synchronous and diachronic) we don´t reach a range without laws at all. Each system is in the domain of particular laws and each system is a part of a (spatially or temporally) larger system in which the transition happens. Then we speak about “laws of development” (“Entwicklungsgesetze”, Hörz/Wessel 1983: 98ff.). They include the dialectics of the elementary level and the system level too, and therefore the “laws of development” include the “degree of freedom” of the elements.
We can see cycles of evolution with a directed tendency in the Hegelian view. (It is not a question here if the direction can be characterized towards “higher” levels).

We saw even in our dynamic view of laws that there is an infinite set of possibilities, in which conditions select the ”necessarily realizing“ one in the equations. In our evolutionary view we see that all ”essential processes in nature are non-linear, determined chaotic and therefore ramifying“ (Zimmermann 1990: 58).

Dynamic aspect	Stochastic aspect	Probabilistic aspect
If we analyse the past, we can see an uninterrupted, but sometimes “bended” way from the past to our present state. Each state has a particular predecessor, from which several maybe (in this past time) accidental conditions lead to the present state. There is a dynamic connection from past to our present time. Our present state is the “necessary realization” of the formerly existing possibilities.	In each present-time there is the possibility of different futures, depending on the conditions and the behaviour of the elements of our system. We can be in one of several states: a) present at a “stable phase” (at an attractor), in which deviations are depressed; b) present at a “bifurcation-point”, in which deviations can become new essential characteristics of the new emerged systems.	For each element/deviation there is the possibility of becoming essential, which is different in several phases of the process.

4.3 Historicity and Lawfulness

We sometimes speak about laws as “stable connections” between changing phenomena. Then we get a contrast. Stability, connected with laws, and change of the phenomena may be a contradiction. But here is a better view: Laws are not connections between things or phenomena that forbid changes. Laws are the “rules of change” beneath the level of phenomena. Laws are the expression of the possibilities of behaviour and change in a different way for the systems and the elements – in their connectedness.

In our synchronous view we can distinguish between one possibility (the directed tendency) for the behaviour of the system and the set of possibilities for the elements. In the diachronic view we have another aspect, the aspect of time. Laws depend on conditions and these conditions can change in time. The conditions can change in such a way that the system can´t exist in its essential quality any longer. Then the system vanishes and its elements vanish too, or they become elements of other systems or they change themselves in such a manner that a new system (with new essential qualities) can emerge. Here we have to consider the well-known phases of self-organized processes.

Because of the changing of the systems the laws will change too. "Therefore possible laws of nature can be identified as such only bit by bit, namely between the critical points of evolution, because the structure building fluctuations dominate at the critical points” (Zimmermann 1991: 61). Biologists usually speak about “evolution of evolution-mechanisms” (see Schlemm 1996: 59 and 206). This seems to be very hard to grasp for cosmologists. When I wrote my first book in 1994 to 1995, in which I take the self organisation of the universe for granted (Schlemm 1996: 28) and suggested searching evolutionary feedbacks in cosmology (p. 186), Lee Smolin wrote his historical book about the historicity of cosmological laws in a “Darwinian cosmos” (I would doubt his concrete mechanisms, but the idea of the evolution of conditions and laws seems to be all right).

We know – beneath such essential qualitative changes – that even in laws the fields of possibility can change. Hörz and Wessel distinguished between modification I, in which the stochastic distribution changes and the essential characteristics do not change and modification II, in which the field of possibilities changes, but the dynamic aspect remains (Hörz/Wessel 1983: 134). Another view differs between two types of possible “innovation”, described by R.E. Zimmermann (2001: 5). One type is based on “internal potential” (“sleeping variables”) and the other type is based on “external potential” (new derivates are being spontaneously included in the system).

The relation of lawfulness and evolution with essentially qualitative changes can be characterised in the following way (see Schlemm 1998). Self-organized evolution follows laws and doesn´t follow laws. Evolution is not lawful, because the laws of the old system don´t determine the further evolution. Evolution is lawful, because the system is kept in a larger system with its own laws and the new system will create its own new laws.

The historicity of laws is for Lee Smolin (2002: 23) an amazing quality of laws – but dialecticians knew this all the time. Maybe we can use a new type of mathematics (negator algebra, see Zimmermann 2001) to describe temporal processes in future. Then it will be essential whether there are only internal potentials (like Kauffmann assumed, see Zimmermann 2001: 6) and the field of possibilities would be determined all the time (out of all time, like Schelling said) or if real novelty can emerge, i.e. something that is not pre-given “out of all time”.

But in both cases we can´t find out what will happen in the future. I prefer the second view: that there is the possibility of emerging new states, which are not pre-given in the eternal “substance”. But even if one assumes that there is such a substance from which the space-temporal world emerged/s, we – as beings in space and time – can´t find out what will and what shall happen in principle.

Science as knowledge of laws can´t determine in advance what we have to do, because there is no "one right" way. If science has the real, changeable conditions of possibilities as its topic, it can be a critical one. Science has two possibilities: Science can recognize the conditions of all connections and tell us: "if this…then that". This enables instrumental acting. The conditions are accepted as given conditions. But if the conditions are grasped as changeable, then our thinking is not only interpreting, but becomes comprehending (for this difference between "deuten" and "begreifen" see also Holzkamp 1985) and "critical".

References:

Arshinov, Vladimir I./Budanov, Vladimir G. (2002) *Cognitive foundations of synergetics.* Paper for the EU-INTAS-Project "Human Strategy in Complexity. Philosophical Foundations for a Theory of Evolutionary Systems".

Ayer, Alfred Jules (1976) *Die Hauptfragen der Philosophie.* München. R. Piper & Co.

Bloch, Ernst (1962/1985) *Subjekt-Objekt. Erläuterungen zu Hegel.* Frankfurt am Main. Suhrkamp.

Born, Max (1961/1963) *Bemerkungen zum statistischen Determinismus der Quantenmechanik.* In: Born, Max (1963) *Ausgewählte Abhandlungen. Zweiter Band.* Göttingen: Vandenheock&Ruprecht.

Budanov, Vladimir/Savicheva, Natalya (2002) *Principles of Synergetics*. In this Book.

Everett Hugh III (1957/1983): *„Relative State" Formulation of Quantum Physics.* In: Wheeler, John, A./Zurek, Wojciech H. (Ed.) (1983) *Quantum Theory and Measurement.* Princeton, New Jersey: Princeton University Press. pp 315-323.

Hempel, Carl G. (1965) *Aspects of Scientific Explanation and other Essays in the Philosophy of Science*. New York. The Three Press.

Hergett, Waldemar: *Dekohärenz.* http://www.mpi-hd.mpg.de/ato/lasercool/teaching/Materiewellen/dekohaerenz.pdf

Hermann, Grete (1935) *Die naturphilosophischen Grundlagen der Quantenmechanik.* Naturwissenschaften 23 (1935), pp. 718-721.

Holzkamp, Klaus (1985). *Grundlegung der Psychologie.* Frankfurt, New York. Campus.

Hörz, Herbert (1964) *Atome. Kausalität. Quantensprünge. Quantentheorie - philosophisch betrachtet*. Berlin. Deutscher Verlag der Wissenschaften.

Hörz, Herbert (1974) *Marxistische Philosophie und Naturwissenschaften.* Berlin: Akademie-Verlag.

Hörz, Herbert/ Wessel, Karl-Friedrich (1983) *Philosophische Entwicklungstheorie. Weltanschauliche, erkenntnistheoretische und methodologische Probleme der Naturwissenschaften.* Berlin. VEB Deutscher Verlag der Wissenschaften.

Hörz, Herbert (1990) *Determination und Selbstorganisation.* In: Niedersen, Uwe (Hrsg.) *Komplexität - Zeit - Methode IV. Wachstum. Muster. Determination.* Halle. pp 31-39.

Hörz, Herbert (2001) *Philosophische Reflexionen zur Struktur der Kausalität.* Unpublished Ms. November 2001.

Meier, Wolfgang/ Zimdahl, Winfried (1986) *Einige Aspekte der Interpretation des quantenmechanischen Messprozesses.* In: Wiss. Zeitschr. Friedrich-Schiller-Univ. Jena, Naturwiss. R., 35. Jg. (1986), H.6, pp. 781-788.

Myelkov, Yuriy (2002) *Spontaneity of Emergence Events and the Formation of Fact.* Paper for the EU-INTAS-Project "Human Strategy in Complexity. Philosophical Foundations for a Theory of Evolutionary Systems". In this book.

Müller, Rainer *Dekohärenz - vom Erscheinen der klassischen Welt.* http://www.cip.physik.uni-muenchen.de/~milq/kap6/images/decoher.pdf

Niedersen, Uwe (1988) *Ordnungsgesetzlichkeit und komplexographisches Handeln.* In: *Komplexität – Zeit – Methode (III). Physikalische Chemie – Historie: Muster und Oszillation*. Halle (Saale). Martin-Luther-Universität Halle-Wittenberg. Wissenschaftliche Beiträge 1988/56 (A 110).pp 40-68

Niedersen, Uwe (1990) *Diskussion.* In: Niedersen, Uwe (Hrsg) *Komplexität – Zeit – Methode (VI). Wachstum. Muster. Determination.* Halle(Saale) Martin-Luther-

Universität Halle-Wittenberg. Wissenschaftliche Beiträge 1990/20 (A 124), pp. 78-79.

Popper, Karl (1989) *Logik der Forschung.* Tübingen. J.C.B. Mohr (Paul Siebeck).

Röseberg (1975) *Determinismus und Physik*. Berlin: Akademie-Verlag.

Ruben (1977) *Das Entwicklungskonzept in der Naturerkenntnis.* in: Redlow, Götz/ Stiehler, Gottfried (1977) *Philosophische Probleme der Entwicklung.* Berlin. Akademieverlag. pp. 97-128

Schlemm, Annette (1996) *Daß nichts bleibt, wie es ist... Philosophie der selbstorganisierten Entwicklung. Band I: Kosmos und Leben*. Münster. LIT-Verlag.

Schlemm, Annette (1998) *Selbstorganisation, Dialektik und wir.* In: Naturwissenschaftliches Weltbild und Gesellschaftstheorie, Texte zur Philosophie, Heft 5, Leipzig. pp. 55-65.

Smolin, Lee (1995) *A Theory of the Whole Universe.* http://www.edge.org/documents/ThirdCulture/z-Ch.17.html

Smolin, Lee (2002) *Warum gibt es die Welt? Die Evolution des Kosmos.* München. Deutscher Taschenbuch Verlag.

Schrödinger, Ernst (1922) *Was ist ein Naturgesetz?* In: Schrödinger, Ernst (1962) Was ist ein
Naturgesetz? Beiträge zum naturwissenschaftlichen Weltbild, München/Wien. pp 9-17.

Schrödinger, Ernst (1944/1984) *The statistical Law in Nature.* In: Schrödinger, Erwin (1984) *Gesammelte Abhandlungen. Band 1. Beiträge zur statistischen Mechanik.* Wien: Verlag der Östereichischen Akademie der Wissenschaften.

Wheeler, John, A. (1980/1983) *Beyond the Black Hole.* In: Wheeler, John, A./Zurek, Wojciech H. (Ed.) (1983) *Quantum Theory and Measurement.* Princeton, New Jersey: Princeton University Press. pp. 209-210.

Wheeler, John, A./Zurek, Wojciech H. (Ed.) (1983) *Quantum Theory and Measurement.* Princeton, New Jersey: Princeton University Press.

Zeh, H.D. (1970) *On the Interpretation of Measurement in Quantum Theory.* In: Wheeler, John, A./Zurek, Wojciech H. (Ed.) (1983) *Quantum Theory and Measurement.* Princeton, New Jersey: Princeton University Press. pp 342-349.

Zimmermann, Rainer E. (1991) *Selbstreferenz und poetische Praxis. Entwurf zur Grundlegung einer axiomatischen Systemdialektik.* Cuxhaven. Junghans-Verlag.

Zimmermann, Rainer E. (2001) *Basic Aspects of Negator Algebra in SOC.* http://www.arxiv.org/pdf/nlin.AO/0105065

The Spontaneity of Emergent Events and the Formation of Facts

Yuriy Myelkov

The contemporary development of new scientific conceptions enables talking about an undergoing scientific revolution, which results in the becoming of a completely new type of scientific paradigm. The new science finds its objects of interest being complex and unique self-organizing systems; in order to achieve the accurate world view, contemporary science turns to philosophy – indeed, the current situation of a global crisis requires the combination of the efforts and activities of every human culture form: science, philosophy, religion and the arts. It can be noted that one of the most important features of the new situation is the attempt to exclude old classical dichotomies, the attempt to find a certain "*third way*" between classical Scilla and nonclassical Haribda. According to this feature, it would seem quite natural to call the new science "post-non-classical" (Styopin 1989).

If we look on the fundamentals of the new science, we would easily notice its specifications in respect to a comparison to past stages of science´s development. I intend to take a look on such phenomena as *event* and *fact* – while the former turns out to be the unit of the scientific world picture necessary for outlining the philosophical ontology of modern science, the latter serves as the unit of scientific knowledge, thus comprising the epistemological base for science.

Classical science does not allow the distinction and philosophical investigation of fact and event. These two notions, and especially the first one, had retained their intuitive, everyday meaning. Fact could be understood as both a real event and our knowledge of it. The notion of event is introduced into classical science by Galileo: in the Universe in motion, event is considered to be a change of state that happens every moment and at every point of space. Local events are determined by the motion of the global Universe; that is why all events are correlated between each other – just as each state of affairs contains all the truth of every other state (Prigogine/Stengers 1986). Events are considered as manifestations of laws; as such, they all happen similarly, and could be repeated in homogeneous space – under the perspective of One Infinite Mind of the Transcendental subject – under exact circumstances, ceteris paribus (see Fig. 1).

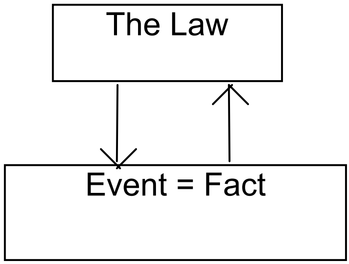

Fig. 1.

Non-classical science, which emerges at the very beginning of the 20th century, changes this view. The investigation of the micro-world is possible only by the use of specific devices that are part of the macro-world, as well as the investigator himself. Thus, the gap between system and observer emerges, and the results of observation are determined not solely by events but by the situation of the device as well. The scientific fact as the unit of knowledge no longer tends to be a synonym of a real event, but appears as a reflection of the appropriate event under certain circumstances of devices and observers. Another important change is that of determinism: an event is no longer considered being a mere manifestation of a law, it can happen by chance, according to the principle of probability (see Fig. 2).

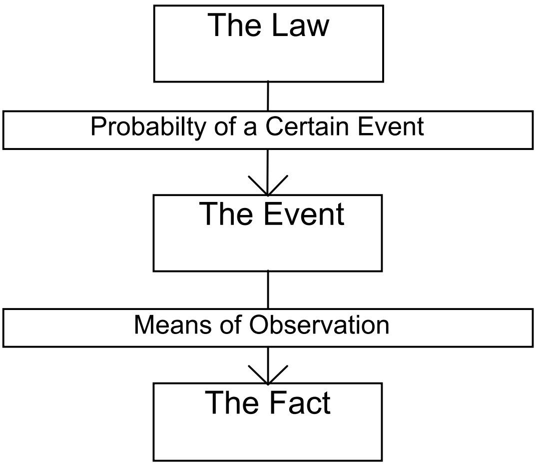

Fig. 2.

Current, post-non-classical science draws a brand new picture of reality. Self-organisation of complex systems provides the possibility for reconstructing a new philosophical ontology. First of all, the specific feature of it is the noted double negation, an attempt to describe a third way between determinism and indeterminism (Wolfgang Hofkirchner calls this "incomplete determinism", see his contributions in this book), an attempt to ground the complimentarity of chance and necessity. According to I. S. Dobronravova (Dobronravova 1990) in the theory of evolutionary systems chance is a supplement to necessity, and not just its "manifestation". The bifurcation point turns out to be a place for the emergence of spontaneous choice between different paths for the system´s future development. This feature has led scientists appeal to Hegel´s dialectic (Dobronravova 1990) in order to better understand the nature of the contemporary scientific revolution.

I think that *spontaneity* is the correct term for the "third kind" of determination that is opposed to both determinism and indeterminism. The term “spontaneous” means literally “arbitrary”; for example Epicure used it to explain the atoms´ deviation from determined paths. Sometimes ´spontaneity´ is still used as a synonym for “chance”; however, in philosophy the meaning of spontaneity rather combines both chance and necessity. Thus, in Leibnitz´s philosophical system spontaneity characterized the freedom of action for monads, and this freedom indeed presupposed the preestablished harmony.

Vasily Nalimov, the prominent Russian scientist, founded his philosophical system on the notion of spontaneity According to Nalimov, spontaneity of emergence means a multiplicative mixing of predetermined principles with freedom of choice (Nalimov 1989). Spontaneous events are not determined by causal relationships, however they do bear elements of necessity. In fact, spontaneity can be considered as *unpacking* or unfolding "the continuum of senses" that is potentially hidden in nature.

Thus, emergence reveals necessity, as the available state of the system does determine the future development of the system, independent of the choice the system would make at the bifurcation point. This means according to V. V. Nalimov that the spontaneity of emergence poses the question of the relationship of the Future and the Past in correlation with the situation that emerges in the Present. The Future exists in its unrealized potentiality and its realization reveals freedom of choice, chance – but it is no longer something completely arbitrary, something meaningless. Indeed, spontaneity of emergence proves that self-organisation is, according to the title of Nalimov´s article, "a creative process" (Nalimov 1994).

The new point of view enabled by the development of new science and its philosophical reflections, while rejecting the sole reign of classical determinism allows to notice and to investigate new levels of causal relations. J. Wolf in his attempt to develop an ontology for modern science (Wolf 1991) proposes a distinction between two types of causality. The traditional scientific type of causality is the one that happens in space and time: if certain conditions exist and certain events occur at some time, then these would cause another set of conditions and events at a later time.

The other type of causation, the vision of which is enabled by the development of the philosophical investigations of the new scientific paradigm, occurs between wholes and their parts – J. Wolf calls it "holistic causation". This type of causality does not happen in time – correlated events may appear perfectly simultaneous. J. Wolf argues that "this is so because one of these events is not the result of another in time and space, but both events are the result of the same «super-event»".

This holistic causality indeed corresponds to the modern views on complex self-organizing systems. In quantum physics, "superluminal causation" has been observed as causation with higher speed than light: in the Aspect experiment, the polarization of one photon changed instantaneously with that of its twin photon (Wolf 1991). In psychology, Carl Jung issued the idea of "synchronicity" – "a causal connecting principle" (Jung 1997). Synchronicity is yet another type of "exotic causality", two parallel events appear to be caused accidentally because no traces of causal relations between them can be found. Investigation of this kind of relationship supposes reference to different forms of para-science, to telepathy, "out-of-body experience", and so forth; of course, the scientific character of such fields of study is still being much doubted by contemporary scientific community.

It can be noted that the new science views objects as wholes. Non-classical science discovers that the human being is an observer that belongs to a macro-world while the observed particle is part of the subatomic world. Post-non-classical science reveals yet another level of knowledge: the human subject appears not just an observer, but also as a "*meta-observer*" (a term introduced by V. Nalimov). In other words, the human being is no longer solely a subject, but a meta-subject as well (Krymski 2000), i.e. both the human subject and the object of reality are united by their belonging to a higher level unity of the whole (Fig. 3).

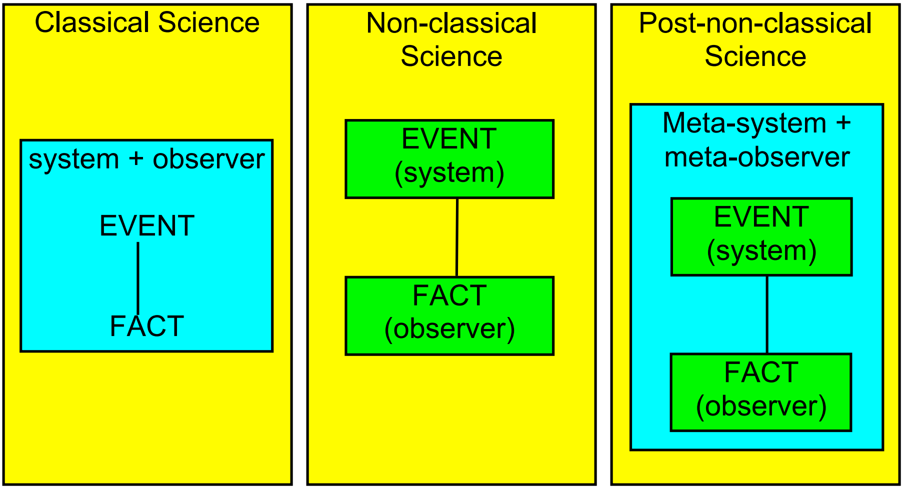

Fig. 3.

Science deals not with events as such, it deals with facts. Classical science assumed no distinction between these two phenomena – they were united. Non-classical science introduced the idea of a variety of systems; fact and event were separated. Modern, post-non-classical science advances toward the new unity while not losing variety. It is the unity of both the classical thesis and the non-classical antithesis. While the emergent spontaneous event and the fact of science are separated on the one level, on the higher level they do belong to one whole, like human subject and object of reality.

The event in post-non-classical science is not only spontaneous; moreover, it has its own meanings, it regains the possibility to change the system´s evolution (Prigogine/Stengers 1994). In other words, event appears as the choice made by the system at the bifurcation point, which represents a realization of one out of a variety of potential development paths – and thus it is of value to the system. However, the notion of "potentiality" bears a certain reflection of the classical dichotomy between "actual / potential". And this opposition is also doubted in contemporary science, this has to do with the concept of "virtuality" as "the third way". Virtualistics is a new transdisciplinary approach like synergetics that turns to the conception of a variety of ontological realities. Virtual, as it is understood by N. Nosov (Nosov 2000) could be seen as an intervening form between "actual" and "potential". The continuum of possible choices and possible events forms a complex of virtual entities, all of them existing in a certain reality. We should in this context remember such ideas as "possible worlds" of Leibnitz or the "Many Worlds" interpretation of quantum mechanics by H. Everett and B. deWitt.

The event of reality is transformed into the fact of science by its semantic interpretation. In non-classical science fact means an event observed under certain specific circumstances – a fact is an event in a context of the employment of a specific device. The variety of possible situations and its philosophical comprehension resulted in Bohr´s principle of complementarity. However, philosophy of the 20th century has demonstrated that the non-classical way of thinking may result in an unintended relativism. It is the new, post-non-classical type of science that shows a way to avoid the deadlock of relativism.

It must be noted that the term "post-non-classical science" is in no way a categorical "new age" phenomenon, similar to "postmodernism". Postmodernism corresponds rather to a non-classical world-view in its unending relativism that denies anything absolute, especially values, and stands for a dichotomical style of thinking (postmodern vs. modern, new vs. old, etc.). As it has already been noted, post-non classics appears as a double negation, as a rather dialectical synthesis of classical and non-classical thinking, and dialectical ideas are now being applied in the natural sciences, in synergetics, and in evolutionary system theories. Post-non classical science includes human values (Styopin 1989). Whereas classical thinking postulates monism, only one reality being "true", and non-classical ideas turn to variety, pluralism as opposition to classical monism, post-non-classical thinking tends to operate in the manner of a "unity in variety".

First of all, in post-non-classical science, fact turns out to be an event in the context of human Weltanschauung, and not only in the context of a device situation. The new science considers an event of reality as something that possesses sense and has a certain value. And it is the fact that adds *sense* to an event. Alongside with the emergence of the event there is an emergence of sense that characterizes the event. The fact of science "unites" these two phenomena allowing comprehension of the event, giving it a place in human worldviews (see Fig. 4).

Besides, the continuum of possible senses and the continuum of possible events are interconnected. The facts of science could be changed, allowing events to obtain another sense. The philosophical investigation of modern science reveals that there always is a broader system (a meta-system), a meta-context, that determines the possible contexts of events that lead to the formation of scientific facts. The continuum of senses, which are available for "unpacking" through a self-organisation process, is based on the present state of development of the meta-system. Human knowledge is based on the present state of the evolution of humankind, and it is determined by the whole human cultural development.

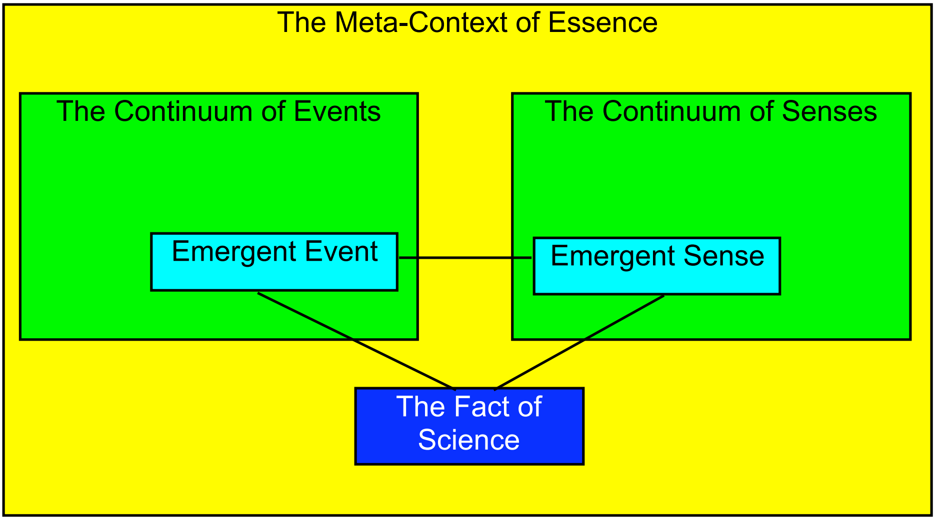

Fig. 4.

I would like to provide the following example in order to describe the existence and functionality of the meta-context. In astronomical science in the 1960s there was an actual problem concerning the search for extraterrestrial civilizations. Several programs were developed and carried out, like looking for artificial space radio signals or sending signals containing information on humankind, but no results have been achieved. Russian radio astronomer B. Panovkin has proposed an interesting hypothesis for solving this paradox (Panovkin 1976). It appears that human beings are the products of self-organisation and form a united system with their environment. Thus, according to B. Panovkin, the "objectivity" of the environment cannot be separated from the "objectivity" of the living organisms. In other words, the way we see reality is the way *we see* reality. Human knowledge is determined by the whole evolution – both that of nature and that of humankind; this knowledge cannot be separated from the meta-system of nature and culture or be considered as "knowledge as such". That is, the information human radio astronomers used to send into the outer space in 1960-s could be received and understood only by very anthropomorphic subjects, whose evolution path was extremely similar to ours.

The present state of meta-system forms a meta-context for both real events and human scientific knowledge that consists of facts as semantic interpretations of events. While sense and context of concrete events can be changed in pursuit of an invariance of the ontological unit, the meta-context remains unchanged, as it forms the base and the essence of our existence and our knowledge. It is this meta-context that makes our knowledge and our perceptions possible; without it we would neither be able to understand some event as fact, nor would we perceive something as an event of reality at all. The existence of such a meta-system can lead to the discovery of deep levels of reality, revealing the fundamentals of essence of both nature and culture, spirit and matter (see Kulakov 1998). Besides that, the cultural reference of senses inside scientific facts allows reconsidering the problem of the relations between scientific knowledge and human values; indeed, it opens a new way of world development in the 21st century.

The ideas stated here certainly form only a very approximate draft of a new ontology for nonlinear science and require a lot of attention from philosophers and other researchers; but nevertheless we can now summarize some points of it. The dialectical development of the human knowledge system of the world has lead to the formation of a new scientific paradigm that can be considered as post-non-classical one, as a double negation of classics and non-classics. The becoming of the "third way" results in the growing inefficiency of dichotomies like ´determinism / indeterminism´, ´idealism / materialism´, ´nature / culture´. The emergence of events occurs spontaneously, combining elements of necessity with freedom of choice. Facts as scientific representations of real events are formed by semantic interpretation of events, based on the context of senses. Events can be reinterpreted on the ground of a meta-context that can be seen as a continuum, as a meta-system of all potential senses that can be applied to events under the circumstances of the existence of humankind.

References:

Dobronravova, I. S. (1990) *Synergetics – the Becoming of Nonlinear Thinking*. Kiev. Lybid. 152 p. (in Russian)

Jung, C. G. (1997) *Synchronicity: an Acausal Connecting Principle*. In: Jung, C. G. (1997) Synchronicity. Moscow/Kiev. Refl-book/Vakler. pp. 195 – 307 (in Russian).

Krymski S. B. (2000) *Philosophy as the Path of Humanity and Hope*. Kiev. Course. 308 p. (in Russian).

Kulakov, Yu. I. (1998) *The Search for Scientific Truth Leads to God*. 20th World Congress of Philosophy. Philosophy of Science. http://www.bu.edu/wcp/Papers/Scie/ScieKula.htm.

Nalimov, V. V. (1989) *Spontaneity of Consciousness. Probabilistic Theory of Senses, and Semantic Architectonics of Personality*. Moscow. Prometei. 288 p. (in Russian).

Nalimov, V. V. (1994) *Self-organisation as a Creative Process: Philosophical Aspects*, In: Mishra, R. K. (Ed.) (1994) *On Self-organisation. An Interdisciplinary Search for a Unifying Principle*. Berlin. Springer Verlag. pp. 270-279.

Nosov, N. A. (2000) *Virtual Psychology*. Moscow. Agraf. 432 p. (in Russian).

Panovkin, B. N. (1976) *Objectivity of Knowledge, and the Problem of Semantic Information Exchange with Extraterrestrial Civilizations*. In: *Philosophical Problems of 20th Century Astronomy*. Moscow. Nauka. pp. 240-265 (in Russian).

Prigogine, I./Stengers, I. (1986) *Order out of Chaos*. Moscow. Progress. 432 p. (in Russian)

Prigogine, I./Stengers, I. (1994) *Time, Chaos, Quantum*. Moscow. Progress. 266 p. (in Russian)

Styopin, V. S. (1989) *Scientific Knowledge and the Values of Technogenic Civilization*. In: Voprosy Philosophii, 1989, 10. pp. 3-18 (in Russian).

Wolf, J. (1991) *Revolution in Common Sense or Quantum Metaphysics*. http://home.sprynet.com/~jowolf/essay.htm.

II. Principles of Synergetics

II.1. General Systems

Evolutionism, the Anthropic Principle, and New Rationality

Vyacheslav Stepin

1. Introduction: The Emergence of Post-Non-Classical Science

In epochs of global scientific revolutions when all the components of the foundations of science are being reconstructed a change in scientific rationality takes place. One can single out three basic historical types of rationality, i.e. *classical, non-classical and post-non-classical science*. Classical science assumes that true knowledge of an object is conditioned by the elimination, in the process of theoretical explication and description, of all that which has to do with the subject, its goals and values as well as the means and procedures of its activity. Non-classical science (its example being a relativist quantum physics) takes into account the relation between the knowledge of an object and the nature of the means and procedures of the activity in which the object is discovered and cognized. Nevertheless, relations between intrascientific and social goals and values are still outside scientific reflection, though defining implicitly the nature of knowledge (defining what it is that we isolate and conceive in the world as well as the way we do it). The post-non-classical type of scientific rationality extends the field of reflection on activity. It is aware of the relation not only between the knowledge of an object and the specific nature of the means and procedures of activity, but between this very knowledge and the structure of the goals and values of such activity as well. At the same time the relation between intrascientific and extrascientific goals is brought to light. In overall investigations of complex self-developing systems more frequently than ever becoming dominating objects in natural science and technology (including the objects of ecology, genetics and genetic engineering, "man – machine – environment" technical complexes, modern information systems, etc.) the elucidation of the ties between intrascientific and social values is performed through social expertise of respective investigation programs.
The historicism of the objects of contemporary natural science along with reflection on the value-related foundations of research remove the opposition between natural and social sciences. True with respect to 19th century science, at present it considerably loses its significance.

The emergence of a new type of rationality does not eliminate those that preceded it historically, it limits their field of application instead. Every subsequent type of scientific rationality introduces a new system of the ideals and norms of cognition, which provides for the assimilation of a respective type of systemic objects, i.e. simple, complex, historically evolving (self-organizing) systems. This brings about a change in the categorical framework of the philosophic foundations of science – in the concepts of thing, process, space, time, causality, etc. (the ontological component), and in the concepts of knowledge, theory, fact, method, etc. (the epistemological component). Finally, a new type of rationality accounts for the alteration in the worldview applications of science. At the classical and non-classical stages of its evolution science was grounded only upon the values of the technogenic civilization rejecting the values of traditional cultures as contradictory to it. Post-non-classical science markedly extends the field of possible worldview meanings with which its achievements accord. It forms part of the contemporary processes of solving global problems and choosing mankind´s vital strategies. Post-non-classical science embodies the ideals of an "open rationality" and actively participates in the search for new worldview guidelines determining the strategies of contemporary civilizational development. It uncovers the proportionality of its own achievements not only to the values and priorities of the technogenic culture, but also to a series of philosophical and worldview ideas elaborated in other cultural traditions (to the worldview ideas of the traditional Oriental cultures and the ideas articulated in the philosophy of Russian cosmism). Post-non-classical science organically enters the contemporary processes of shaping a planetary thinking, of a dialogue of cultures, becoming one of the most important factors of a cross-cultural interaction between the West and the East. The aim of this paper is a look at the development of the post-non-classical science and a discussions of some of its philosophical and worldview implications.

The transition of science to the post-non-classical stage of development has created new premises of forming a common picture of the world (Stepin, Kuznetsova: 1994). For a long time the idea of such an unity existed as an ideal. But in the last third of the 20th century there appeared real possibilities to unite the notions of the three main spheres of being – non-living nature, organic world and social life – into an integral picture on the foundation of basic principles having general scientific status.

These principles do not deny the specificity of each concrete branch of knowledge, but, at the same time, are invariant in the diversity of disciplinary ontologies. The forming of such principles was connected with a revision of the foundation of many scientific disciplines. Such revision is one of the aspects of the great cultural transformation taking place in our age (Capra 1989: 113).

If we were to briefly characterize modern tendencies of the synthesis of scientific knowledge, it must be said that they are expressed in a desire to build a general scientific picture of the world based on the principles of universal evolutionism, uniting into a whole integrity the ideas of systemic and evolutionary approaches.

2. The Notion of Evolution

The becoming of the notion of evolution has quite a long history. Even in the 19th century it was applied in certain spheres of knowledge, but was perceived more as an exception with respect to the world as a whole[1].

The principle of evolution was most completely worked out within the framework of biology and became its fundamental principle since the epoch of Charles Darwin. But up to nowadays it has not been dominating in the natural sciences. In many respects this is due to the fact that for a long time the prevailing scientific discipline that has translated its ideals and norms to other branches of knowledge, has been physics. Traditionally physics investigated the fundamental structures of the Universe, so it had always been among those sciences which had a claim on forming the basic ideas of a general scientific picture of the world. But in the course of most part of its history, physics did not include — in evident form — the principle of development into the set of its fundamental principles.

As to biology, it has not reached the high status of a theoretically developed science, and is now at the stage of theorizing. Its notions dealt with iving nature, which traditionally was not considered as foundation of the Universe. That is why biology, taking part in the construction of the general scientific picture of the world, for a long time did not aspire that its fundamental ideas and principles got a universal scientific meaning and were applied in all other spheres of investigation.

The paradigmatic incompatibility of classical physics and biology was discovered in the 19th century as a contradiction between the theses of Darwin´s theory of evolution and the second law of thermodynamics.

According to the theory of evolution, there permanently appear more and more complicated living systems in the world, organized forms and states of living matter. The second law of thermodynamics demonstrated that evolution of physical

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[1] Incidentally we mean raising the problem in the framework of science while concerning philosophy there were surmised ideas on global cosmic evolution outgoing the science of their own time.

systems leads to a situation of decay when an isolated system is purposefully and irreversibly shifted to the state of equilibrium.

In other words, biological theory spoke about the evolution process as the construction of more and more complicated and organized living systems, while thermodynamics spoke about destruction and permanent entropy growth. These collisions of physics and biology required settlement, and premises for this could be the evolutionary regard of the Universe as a whole, i.e. translation of the evolutionary approach into physics, which would lead to a reformulation of fundamental physical theories. But this situation is characteristic only for science in the last third of the 20th century.

3. Universal Evolutionism: Universal Evolution as a Universal Idea

The universal idea of evolution processes in the Universe are realized in modern science by the conception of global (universal) evolutionism. Its principles let us describe uniformly the enormous diversity of processes taking place in non-living nature, living matter, and society (Moiseev1989: 53).

The conception of universal evolutionism is based on a certain complex of knowledge that stem from concrete scientific disciplines, and, at the same time, includes a number of philosophical, worldview directions. It refers to that layer of knowledge, which is traditionally designated by the term "scientific picture of the world".

Why is it the modern stage of functioning of science that requires the ideas of universal evolutionism as main ones, allowing scientists to work out the general picture of the integral process of development of nature and society? Before answering this question, we are to specify, what universal evolutionism is, and to understand, what contributed to the establishment of its ideas in science, not at the level of metaphysical speculations, but as a generalization of concrete scientific data.

Universal (global) evolutionism[2] is often characterized as a principle that provides the ideas of evolution with extrapolation over all spheres of reality and a consideration of the development of non-living, living and social matters as united, universal evolutionary process.

[2] In the following discourse we will use these terms as synonyms.

It is important to take into consideration that in the 20th century new features of the evolutionary approach itself have emerged, distinguishing it from the classical evolutionism of the 19th century which was more interested in describing the phenomenology of development than the system characteristics of developing objects.

When in the 1940s and 1950s general system theory and the system approach appeared, a fundamentally new content was provided to the conception of evolution. The idea of a systemic consideration of objects turned out as a heuristic method first of all in biology, where it led to working out the problem of structural levels of organisation of living matter, an analysis of different connections both within a certain system and between systems of different grades of complexity. The systemic consideration of object first of all stipulates the uncovering of the integrity of the system studied, its intercommunication with the environment, an analysis of the properties of the components and their intercommunication within the system. The systems approach, developed in biology, regards objects not as mere systems, but as self-organizing systems of open character. N. N. Moiseev notes that today we see the processes of evolution, self-organisation of matter more widely than at Darwin´s time, and the notions of heredity, changeability, selection, for us are filled with other, deeper content (Moiseev 1986: 25).

From his point of view, everything happening in the world, the operation of all natural and social laws, can be presented as permanent selection, when only several classes and types of states are selected from the diversity of possibilities. In this sense all dynamic systems possess the capability “to make choices” although the concrete results of a “choice” as a rule might not be predicted in advance.

N. N. Moiseev indicates that we can distinguish two types of mechanisms regulating such "selection". On the one hand, adaptative ones, under effect of which the system does not obtain fundamentally new properties; on the other hand, so called bifurcative ones, connected with the radical reconstruction of the system. But, besides these mechanisms, in order to explain self-organisation, we are to point out one more characteristic of the self-organisation processes, marked by Moiseev as principle of the “entropy economy”, which gives preference to complicated systems compared to simple ones. This principle says that if several types of organisation of matter are possible, not contradicting the conservation laws and other principles, the one which has most chances for stability and further development is that one, which allows scientists to utilize outer energy to the largest scale and most effectively (Moiseev 1986: 25).

The formation self-organizing systems can be regarded as a special period of the developing object, a kind of "synchronous section" of some stage of its evolution. The evolution itself can be presented as the transition from one type of self-organizing system to another ("diachronic section"). As a result, the analysis of evolutional characteristics is closely connected with the systemic consideration of objects.

Universal evolutionism means combination of evolutionary ideas with the systems approach. In this respect, universal evolutionism not only applies the notion of development to all spheres of being (establishing universal connections between non-living, living and social matter), but also overcomes the narrowness of a phenomenological description of development, linking this description with the ideas and methods of systems analysis.

Many natural scientific disciplines contributed to the justification of universal evolutionism (Calvin 1971). But the decisive part in its establishment as a principle of construction of the modern general scientific picture of the world was played by the three most important conceptual trends in the science of the 20th century: first, the theory of a non-stationary Universe; second, synergetics; third, the theory of biological evolution (concerning the latter especially the notions of the biosphere and the noosphere are important).

4. New Trends in 20th Century-Cosmology

The beginning of the 20th century was marked by a chain of scientific revolutions, among those an essential place belonged to the revolution in cosmology. It played an important role in establishing the idea of evolution in the sciences of non-organic nature and caused a radical reconstruction of the notions of the Universe.

We are talking about the theory of the expanding Universe. This theory introduced the following ideas of cosmic evolution: about 15 to 20 billion years ago the Universe started to expand from the point of singularity as a result of "the Big Bang"; the Universe first was hot and dense, but cooled down during the course of its expansion, and matter, while cooling down, was condensed in galaxies. The latter ones, in their turn, were broken up into stars, integrated and formed large clusters. In the process of emergence and decay of the first generations of stars heavy elements were synthesized. After the stars turned into red giants, they threw out matter condensed in dust structures. Gas-dust clouds formed new stars, and the diversity of cosmic bodies (Silk 1982: 16-17) appeared. The ´Big Bang´ theory created a general picture of the evolution of the Universe in. At its origin were the discoveries of A. A. Friedman which casted doubts in the postulate of the Universe as stationary in time. Analyzing Einstein´s "world equations", describing metrics of four-dimensional curved space, Friedman found their non-stationary solutions and offered three possible models of the Universe. In two of them the radius of curvature was to grow, and the Universe, correspondingly was conceived as extending. The third model suggested the picture of a pulsating Universe with a periodically changing radius of curvature (Friedman 1965).

The model of the expanding Universe led to three important predictions, which later could be tested by means of empirical observations. First, with the expansion of the Universe, galaxies are moving away from each other at a speed proportional to the distance between them; second, this model predicted the existence of microwave background radiation, piercing through the whole Universe and being relic of its hot state of the beginning of its expansion; third, this model predicted the formation of light chemical elements out of protons and neutrons at the first minute after the expansion had begun. (Guth and Steinhardt 1984).

The model of the expanding Universe has essentially transformed our ideas of the world. It required that we should include the idea of cosmic evolution into the scientific picture of the world. This was the way to create a possibility for describing the non-organic world in terms of evolution, uncovering common evolutionary characteristics of the different levels of its organisation and, finally, constructing an integral picture of the world on this foundation.

In the middle of the 20th century there was a new impulse for evolutionism. The theory of expanding Universe, in spite of describing the events which took place a second after the beginning of the expansion quite well, faced considerable difficulties in its attempts to characterize the most mysterious stages of that evolution from the initial explosion to the world seconds after it. The answers to these questions, to a large extent, were given within theory of the inflating Universe. This theory emerged as a connection cosmology and physics of elementary particles. The key element of the inflating Universe is the so called inflation phase, i.e. the stage of accelerated expansion. It lasted for 10-32 seconds, and during that time the diameter of the Universe increased 1050 times. After enormous expansion, once and for all the phase with broken symmetry was established, and that led to a change of the state of vacuum and, finally, to the emergence of various types of elementary particles (Guth and Steinhardt 1984). In our Universe matter prevails over antimatter, and in this respect we live in an asymmetric Universe. The prediction of the asymmetry of matter and antimatter in the Universe was the result of a combination of the ideas of "Great unification" in the elementary particles theory with the model of the inflating Universe. Within the program of the "Great unification" scientists put forward the idea of an initial symmetry, uniting the main types of interaction (strong, electromagnetic, weak and gravitational). It is supposed that in the very beginning of the Universe´s evolution (10-46 seconds after "the Big Bang") spontaneous symmetry breaking caused the "split" of the initial state and the emergence of the four main interactions of nature. In this approach the types of interaction are presented not as being given once and for all, but as emerging in the process of evolution.

Modern science has spread the idea of development to such an extent so that the fundamental structures of the Universe could be included, establishing connections between evolution of the Universe and the formation process of elementary particles. All this gave us the possibility to consider the Universe as a unique laboratory for the verification of the modern theories of elementary particles and their interactions (Linde 1984), *(Advances of Physical Sciences*: 177-214), (Guth and Steinhardt 1984).

The theory of the inflating Universe has radically changed our view of the world: in particular, it changed "the view at the Universe as something homogenous and isotropic, and there emerged a new view of the Universe as consisting of many locally homogenous and isotropic mini-universes, where properties of elementary particles, the amount of vacuum energy and the dimensionality of space-time can vary" (Linde 1984: 210).

Transforming the established physical picture of the world, the theory of the inflating Universe gives a new impulse to the formation of a general scientific picture of the world that is basen on the ideas of global evolutionism. It also requires corrections of the philosophical foundations of science, putting forward a number of important problems that have a worldview character. The new theory allows us to consider the observable Universe only as a small part of the universe as a whole, and that means that we have the right to assume existence of quite many evolving universes (Guth and Steinhardt 1984). In the process of evolution most of them are unable to result in such a diversity of organisational forms that is characteristic for our Universe (Metagalaxy). Why is our Universe as it is, and how is the progressive evolution of matter possible in it? Can we regard the appearance of life on the Earth, as well as the origin of humanity, as something random, or is the formation of man a regular process in the evolving Universe? What place belongs to this event in the processes of evolution, how does it influence the course of evolution?

One possible answer is based on the so-called “anthropic principle” that has been founded on the hidden assumption of the existence of a multitude of universes where life appears under special conditions. According to one variation of the anthropic principle, what we expect to observe, should be limited by the conditions necessary for our existence as observers. Although our position is not necessarily a central one, it is inevitably in some sense a privileged one (Carter1974). This formulation of the anthropic principle let B. Carter concentrate his attention mainly on the “weak” and “strong” versions of the principle which have been widely interpreted. According to the first one, our position in the Universe is inevitably privileged in the sense that it should be compatible with our existence as observers. The "strong" anthropic principle states that the Universe must be shaped in such a way so that at certain stage of evolution the existence of observers (Carter 1974) is permitted. Many times scientists emphasized the wonderful coordination of the main properties of the Universe (A. D. Zelmanov, G. M. Idlis, P. Davies and others). Its physical parameters, such as the constants of physical interactions, the masses of elementary particles, the dimensionality of space, are decisive for the existence of the present structure of the Universe, since any violation of one of them could lead to the impossibility of progressive evolution and to the impossibility of our existence as observers. The anthropic principle poses worldview problems for scientists, making them again think about the question of our place in the world and our attitude towards this world. New data obtained in cosmology let us suppose that objective properties of the Universe as a whole create the possibility of the emergence of life and intellect at certain stages of its evolution. The potential possibilities of these processes were set at the earliest stages of development of the Metagalaxy, when numeric values of the world constants, which determined the character of further evolutionary changes, were formed (Kazyutinsky 1989: 199-213). All these results can be evaluated as one of the essential factors of the establishment of the idea of global evolutionism within the modern scientific picture of the world.

5. The Theory of Self-Organisation

Not less important in the formation of these ideas has been the theory of self-organisation (synergetics). It studies self-organizing systems. Such systems consist of numerous subsystems (electrons, atoms, molecules, cells, neurons, organs, complex multicellular organisms, human beings, human communities), paying special attention to the coherent, coordinated state of self-organisation processes in complicated systems of different nature (Haken 1987). There are four characteristicds of a self-organizing system: 1) the system is thermodynamically open; 2) dynamic equations of the system are non-linear; 3) the deviation from balance exceeds critical values; 4) processes in the system occur cooperatively (W. Ebeling). I consider self-organisation as one of the main qualities of moving matter. It includes all processes of self-structuring, self-regulation, self-reproduction. It plays the role of a process leading to the formation of new structures (Klimontovich 1986: 56-58).

For a pretty long time the notion of self-organisation was applied only to living systems; as to objects of non-living nature, it was believed that if they do evolve, they evolve only towards chaos and disorder; this belief was proved by the second law of thermodynamics. But here we came across a radical problem: the question of how systems of such a kind could give birth to objects of living nature that are capable of self-organisation. A methodologically important question concerning the interrelation between non-living and living matter emerged. In order to answer it, we had to change the paradigmatic principles of science and, in particular, eliminate the gaps between the evolutionary paradigm of biology and the traditional abstraction from evolution ideas in the construction of the physical picture of the world.

For a long time the functioning of physics excluded the "development factor" from its considerations. Classical science mainly paid attention to stability, balance, uniformity and order. Its objects were only closed systems. Usually, these were simple objects, and knowledge about the laws of their development let scientists, based on information of the state of the system in the present, predict its future and reconstruct its past. The mechanistic picture of the world had a timeless character. Time was not an essential element, it was considered as reversible, i. e. the states of objects in the past, present and future were practically indistinguishable. In other words, the world is arranged simply and submits to fundamental laws in this paradigm, it is reversible in time (Prigogine and Stengers 1984). All these principles and approaches were concrete expressions of the non-evolutionary paradigm of classical physics. Processes and phenomena, which did not correspond to this scheme, were regarded as exception; it was believed that they can be neglected.

The gradual erosion of the classical paradigm in physics started as early as in the 19th century. The first important step was the formulation of the second law of thermodynamics, which cast doubt on the timeless character of the physical picture of the world. According to the second law, the energy content in the Universe is depleting, and the world machine in fact has to reduce its activity, approaching the thermal death. Events are not reproducible in principle, and that meant that time had direction. There appears the idea of the "arrow of time" (Prigogine and Stengers 1984).

Further development of physics led to an understanding of the scantiness of the idealization of closed systems and the description of real physical processes in terms of such systems. The overwhelming majority of natural objects are open systems, they exchange energy, matter and information with the surrounding world, a decisive role in the world is in fact played by unstable, non-equilibrium states. Fundamental sciences dealing with non-living nature — physics, chemistry, cosmology — more and more often faced the necessity to take these features into account. But the old theory turned out as unfit for their description. The traditional paradigm could not cope with the growing multitude of anomalies and contradictions, leaving many discovered phenomena unexplained[3].

There appeared a need to work out a fundamentally new approach, adequate to objects and processes drawn into the orbit of investigation. An important contribution to working out such an approach was made by Ilya Prigogine´s school. Researches of that school demonstrated that, moving away from equilibrium, thermodynamic systems get fundamentally new properties and start submitting to special laws. At a considerable deviation from thermodynamic equilibrium a special type of dynamic state of matter emerges – dissipative structures. According to Prigogine, the type of the dissipative structure to a large extent depends on the conditions of its formation, and external fields may play a special role in the selection of the mechanism of self-organisation (Prigogine and Stengers 1984). This is a conclusion that has wide consequences, if we take into account its applicability to all open systems that have irreversible character. Irreversibility is what is characteristic for modern non-equilibrium states. They "carry the arrow of time" and are the source of order, engendering high levels of organisation (Prigogine and Stengers 1984).

Prigogine and his colleagues developed the idea that the "arrow of time" is displayed in combination with contingency, when random processes are able to cause a transition from one level of self-organisation to another, radically transforming the system. Describing this mechanism, Prigogine emphasized the decisive role of the inner state of the system, the regrouping of its components, etc. in the given development process. The situation defined as appearance of order through fluctuations – random deviations of magnitudes from their average value – is characteristic for dissipative structures. Sometimes these fluctuations can increase, and in this case the existing organisation cannot withstand it and is destroyed. At these breaking points (bifurcation points) it is impossible to predict what direction the further development will take, whether the system will become chaotic, or will pass to a higher level of ordering (Prigogine and Stengers 1984).

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[3] A characteristic example is the Belousov-Zhabotinsky reaction, which is a striking evidence for synergetic effects, but did not get justification at the period of its discovery and was not accepted by scientific community.

Contingency pushes the system to a new way of development, and when a certain way is chosen, determinism again takes effect, and so on, until the next bifurcation (Prigogine and Stengers 1984). Here we see that the more complicated the system is, the more sensibility it displays with respect to fluctuations, and this means that even negligible fluctuations, when intensifying can change the structure, and, in this sense, our world is deprived of guarantees of stability (Prigogine and Stengers 1984).

Prigogine and Glensdorff made an attempt to formulate the universal criterion of evolution, the core of which was the following: under certain circumstances thermodynamics not only does not contradict evolution theory, but can directly predict the appearance of new things. Introducing this rule, the authors evidently tried to create a universal law for both living and non-living matter, the law of self-organisation and evolution of open systems (Klimontovich 1986: 104). The goal was the extension of the class of self-organizing systems, when it became possible to apply phenomena of self-organisation to non-living nature, biological and social processes.

This aspect of application of the ideas of self-organisation was reflected in Erich Jantsch´s work "The Self-organizing Universe: Science and Human Implication of the Emerging Paradigm of Evolution". According to Jantsch, who used Prigogine´s results of scientific researches on thermodynamics of non-equilibrium processes, self-organisation considered as a general process that applies for the whole totality of natural and social phenomena. Proceededing from the assumption that self organisation is a dynamic principle that results in a rich diversity of forms displayed in all structures, Jantsch made an attempt to work out a uniform paradigm able to uncover the all-embracing phenomenon of evolution (Jantsch 1980: 19).

All levels of both living and non-living matter, as well as aspects of social life such as morality and religion are developing as dissipative structures. Seen From this position, evolution is an integral process, parts of which are physical, chemical, biological, social, ecological, social cultural processes. The author is not just distinguishing these levels, but tries to find specific features of each of them. Thus, for living systems, the feature of self-organisation is the function of "autopoesis" as the system´s ability of reproducing itself and conserving its autonomous state with regard to its environment.

Uncovering mechanisms of cosmic evolution, Jantsch regards symmetry breaking as its source. Broken symmetry, prevalence of matter over antimatter in the

Universe causes a diversity of various kinds of forces: gravitational force, electromagnetic weak and strong forces. The idea of "great unification" is the program for the investigation of their common genesis.

Jantsch presents the next stage in global evolution as appearance of the level of life, which is "fine overstructured physical reality" (Jantsch 1980: 19). Jantsch´s characteristic of life can be treated differently. At first sight, we can reproach him with reductionism, but at the same time his elucidation of specificity of living matter allows us to come to a different conclusion: here a genetic connection between living and non-living matter is meant. If we take a look at Jantsch´s conception as a whole, this aspect is one of the most important ones.

A further complication of the initial living systems leads to the emergence of a new level of global evolution – the co-evolution of organisms and ecosystems, and then to sociocultural evolution. At the level of sociocultural evolution reason is presented as a fundamentally new quality of self-organizing systems. It is capable of reflecting over passed stages of evolution of the Universe and foreseeing its future states. Thus Jantsch defines the place of man in the self-organizing Universe. Inclusion of man in it makes him involved in what is happening there. According to Jantsch, the proportionality of people´s world to the rest of the world inserts humanist sense into global evolution (Jantsch 1980: 19).

Jantsch´s conception can be considered as a quite fruitful attempt to make a sketch of the modern general scientific picture of the world that is based on the ideas of global evolutionism. It offers a vision of the world, where all organisation levels are genetically interconnected. The foundations of such a vision are not only philosophical ideas, but also real achievements of concrete sciences synthesized within the integral notion of the self-organizing Universe.

Modern conceptions of self-organisation create real premises for a synthesis of this kind. They let us eliminate the traditional paradigmatic gap between evolutionary biology and physics which, in its basic theoretical constructions, abstracts from the ideas of evolution and, in particular, solves the contradiction between the theory of biological evolution and thermodynamics.

At the modern stage these theories do not any longer eliminate, but stipulate each other, in case we regard classical thermodynamics as some particular case of a more general theory – thermodynamics of non-equilibrium processes.

The theory of self-organisation, conceived in terms of thermodynamics of non-equilibrium processes, reveals important regularities of development of the world.

For the first time we have a scientifically grounded possibility to overcome the old gap between the notions of living and non-living nature. Life does not any longer look like an island of resistance to the second law of thermodynamics. It appears as a consequence of the general laws of physics with its proper kinetics of chemical reactions that take place in conditions far from equilibrium (Glensdorff and Prigogine 1971). It is characteristic that scientists, estimating the role of Prigogine´s conception said that, rediscovering time, it opens a new dialogue between human beings and nature (Toffler 1986: 17).

The ideas that stem from thermodynamics of non-equilibrium systems and synergetics have a fundamental meaning for our worldviews and methodologies, since due to them it became possible to justify notions of development of physical systems and include these notions into the physical picture of the world. It opened new perspectives for understanding the connections between the main organisational levels of the Universe – non-living, living and social matter. If before synergetics there was no conception (which would refer to the class of scientific theories, not philosophical ones) that would allow scientists to collect results, obtained in different spheres of knowledge, into a whole, the emergence of synergetics has given us fundamentally new possibilities to form an integral general scientific picture of the world.

Synergetics lets us pass from "linear" thinking, established within the mechanistic picture of the world, to non-linear thinking, corresponding to the new stage of functioning of science. Most studied objects (natural, ecological, socionatural complexes, economic structures) are open non-equilibrium systems regulated by non-linear laws. They all display the ability to organize themselves, and their behaviour is determined by the preceding history of their evolution (Dobronravova 1991: 7).

The notions of open self-organizing systems find confirmation in different spheres of knowledge, stimulating evolutionary ideas there. Let us mention in this respect the results obtained in modern chemistry and, in particular, in the field of evolutionary catalysis. The theory of evolutionary catalysis made a considerable contribution to the comprehension of chemical evolution, i.e. of its reasons and regularities. Within this theory scientists study special chemical objects with non-equilibrium structural and functional organisation, while chemical evolution itself is regarded as a process of irreversible continuous changes of elementary catalytic systems. In these chemical objects (chemical systems) with non-equilibrium and functional organisation, the order of interacting parts and stability are reached due to a permanent interchange of matter and energy (Rudenko 1987: 70-78).

Synergetics created conditions for an intensive exchange of paradigmatic principles between different sciences. In particular, the application of the idea of self-organisation in biology let scientists generalize a number of special notions of the theory of evolution and thus extended the sphere of their application, using biological analogies in description of very different processes of self-organisation in non-living nature and social life.

As a characteristic example, we can take a look at the application of "Darwin´s triad" (heredity, changeability, natural selection) in modern cosmology and cosmogony. We are speaking about bioanalogies such as "natural selection" of universes, galaxies or stars, "cannibalism in the world of galaxies" etc. (Kazyutinsky 1986: 70).

6. Evolutionary Thinking in Biology and Geology: Vernadsky´s Theory of the Biosphere and the Noosphere

It is necessary to denote that the conceptual apparatus of biology has traditionally played a special role in working out the ideas of evolution. As early as in the classical period there existed tight cooperation of the theory of biological evolution with geology and the young social disciplines.

By employing the ideas of cybernetics and systems, a synthesis of the notion of evolution and the systems approach has been achieved in the 20th century. This was a considerable contribution to the formation of the methodology of universal evolutionism. Achievements in biology of the 20th century can be regarded as a special part of scientific knowledge, which, together with cosmology and the theory of self-organisation, played a decisive role in the formaton of new approaches that have led to the construction of an integral general scientific picture of the world.

In the 1920s in biology a new branch of evolutionary thinking started being formed; that branch was connected with the name of V. I. Vernadsky and is called theory of evolution of the biosphere and the noosphere. Certainly, it should be considered as one of essential factors in giving scientific grounds to the ideas of universal evolutionism.

According to Vernadsky, the biosphere is an integral system that has the highest degree of self-organisation and the ability to evolve. It is the result of a "long enough evolution in interconnection with non-organic conditions" and can be regarded as a regular stage in the development of matter. The biosphere is presented as a special geological object whose structure and functions are determined by the specific features of the Earth and the Cosmos. Regarding the biosphere as a self-reproducing system, Vernadsky said that its functioning is to a considerable extent conditioned by the "existence of living matter in it – the totality of all organisms living there" (Vernadsky 1977: 70).

A specific feature of the biosphere, as well as of living matter, is organisation. "The organisation of the biosphere – the organisation of living matter – should be regarded as equilibria, mobile, permanently oscillating in historical and geological time around an exactly expressible average. Displacements or oscillations of that average are continuously and became apparent not in historical, but in geological time" (Vernadsky 1977: 15).

To maintain its existence, the biosphere as a living system needs dynamic balance. But this is a special type of balance. A system that is in absolute equilibrium is unable to develop. The biosphere is a dynamic system, it is always in development. This development, to a large extent, is realized under the influence of inner interrelations of structural components of the biosphere, and the influence of anthropogenic factors upon it is constantly growing.

As a result of self-development and under influence of anthropogenic factors, there can emerge such states in the biosphere, that lead to a qualitative change of subsystems so that it is compounded. In this respect the unity of changeability and stability is a result of the interaction of its components. The correlation of changeability and stability here plays the part of a dialectic unity of constancy and development, and due to the fact that stability itself is the stability of a process, there is constant development (Vodopianov 1981: 193-194).

Considering the role of anthropogenic factors, Vernadsky noted a growing power of human beings; consequently, their activity causes changes in the structure of the biosphere (Vernadsky 1940: 47). At the same time, man and humanity are closely connected with living matter inhabiting our planet, from which they cannot be separated by physical process (Vernadsky 1977: 13).

The evolutionary process of living beings that is part of the biosphere, also exerts influence upon its inert natural bodies and gets special geological meaning due to the fact that it has created a new geological force – the scientific thought of a social humanity (Vernadsky 1977: 18-19).

Vernadsky noted that we can more and more clearly see an intensive growth of the influence of one species of living matter – civilized humanity – upon the transformation of the biosphere. Under influence of scientific thought and human activity a new state of the biosphere emerges – the noosphere (Vernadsky 1977: 19). "Man is becoming a more and more powerful geological force, and change of his position on our planet coincided with this process. In the 20th century he got to know and embraced the biosphere, by its life humanity has become a whole" (Vernadsky 1944: 117). In Vernadsky´s opinion, "human power is connected with human reason and labour directed by this reason. It should give man a foundation for taking measures that preserve the shape of the planet. At the same time the force of reason will let him leave the bounds of his planet, the more so as the biosphere now is getting a new understanding, it is regarded as a planetary phenomenon of cosmic scale, and, correspondingly, we are to reckon with the idea that life exists not only on our planet" (Vernadsky 1944: 114-115). Life "has always appeared at places in the Universe, where corresponding thermodynamic conditions exist. In this respect we may speak about the eternity of life and its manifestations" (Vernadsky 1934: 82).

In Vernadsky´s conception life is presented as an integral evolutionary process (physical, geochemical, biological) that is included into cosmic evolution as a special component. With his theory of the biosphere and the noosphere, V. I. Vernadsky demonstrated the indissoluble connection of planetary and cosmic processes. An understanding of this integrity has important heuristic value because it in many aspects determines the strategy of further development of humanity. The very existence of man depends on how he shapes his interrelations with his environment. It is no mere chance that problems of the co-evolution of man and biosphere are gradually becoming dominating problems of not only modern science and philosophy, but also of the very strategy of human practical activity, as "further development of the species homo sapiens, its further well-being require an extremely accurate correlation of the character of evolution of human society, its productive forces and the development of nature. But while a correlation of processes, taking place in the world of non-living matter, is provided with the mechanisms of natural self-organisation, a correlation of characteristics of natural systems and society can be accomplished only by Reason and the will of Man" (Moiseev 1990: 40-41).

We may conclude that the theory of evolution and the conceptions of the biosphere and the noosphere that have been created on its foundation, considerably contribute to the justification of the idea of a universal interconnection of all processes and demonstrate the irrevesible character of evolutionary processes, clearly marking time an important factor.

7. Towards an Integral General Scientific Picture of the World

Thus, we can ascertain that modern science possesses all natural scientific data that is necessary to justify the universal character of evolution. The evolutionary approach in the sciences of the second half of the 20th century turns out as closely connected with the system-theoretic consideration of objects. From these positions global evolutionism, which contains the principles of evolution and systemness, can be characterized as interconnection between self-organizing systems of different degrees of complexity. It uncovers the mechanisms of the emergence of new structures in the process of development. Such structures emerge in open systems that are in non-equilibrium states, they are formed due to fluctuations and cooperative (synergetic) effects, and all of this results in the transition from one type of self-organizing system to another. As a result, evolution finally gets an oriented character.

Universal evolutionism allows us to consider an interconnection of not only living and social matter, but to also include non-organic matter into the integral picture of the developing world. It creates a foundation for considering man as object of cosmic evolution, there is a regular and natural stage in development of our Universe responsible for the state of the world into which man himself is immersed.

The principles of universal evolutionism are becoming a dominant synthesis of knowledge in modern science. This is the foundation for the construction of an integral general scientific picture of the world, where the central place belongs to the human being. As a basic foundations of the modern general scientific picture of the world, the principles of universal evolutionism are demonstrating their heuristic value right now, when science has turned to studies of new types of objects – self-developing systems (unlike simple and self-regulating systems which were studied at previous stages of science). Having included a new type of objects into the orbit of scientific investigation, science also has to look for new foundations for its analyses. The general scientific picture of the world, based on the principles of universal evolutionism, is a very important component of such a foundation. It plays the part of a global investigation program that determines the strategy of analysing self-developing systems. This strategy is accomplished at both disciplinary and interdisciplinary levels.

The study of complex, unique developing systems is possible only in the system of interdisciplinary interactions. In this case the general scientific picture of the world as a global investigation program is able "to give a hint", which methods and principles can be translated from one discipline into another, how it is possible to realize a connection of knowledge gathered in different spheres of science, how to include this knowledge into culture at the corresponding stage of functioning of scientific knowledge.

Setting the strategy of research of self-developing systems within concrete scientific disciplines and providing a strategy of interdisciplinary investigations, whose specific weight is growing in modern science, the general scientific picture of the world takes many functions which used to be performed by special scientific pictures of the world. The latter are losing their autonomy, are transformed under the influence of systemic and evolutionary ideas and are included as fragments into the general scientific picture of the world and do not have a claim on having a separate, independent status any longer.

This aspect of development of modern scientific knowledge should be regarded especially. Here we come across fundamentally new (in comparison with previous states of science) tendencies of the historical development of the scientific picture of the world. What was considered as an ideal at the stage of the emergence of disciplinarily organized science, is becoming reality under modern conditions. In place of a poorly connected mosaic of different pictures of studied reality, there emerges a common scientific picture of the world, absorbing the contents of different disciplinary ontologies.

But this development required that scientists should study the preceding development of the scientific disciplines and their pictures of reality and should include new notions from systems science and evolutionism. And when these ideas found support in the theories and empirical facts of the leading spheres of scientific knowledge – in physics, cosmology, chemistry, geology, biology, technical and social disciplines, –they started forming a scientific view of objects as complex, historically developing systems. This view gradually transformed the special scientific pictures of the world, intensifying exchange of paradigmatic principles between them. As a result, they began to naturally unite into an integral system of notions of the Universe, which, as it developed, gave birth to new levels of organisation. Each of the sciences determines the place of its subject in this common picture, connecting it with either certain levels of the world organisation, or with common features that determine the interrelations and genetic transitions from one level to another.

As a result, the relative isolation of special scientific pictures of the world from each other that was characteristic for the development of disciplinary science in the 19th century, is now being replaced by their integration within the general scientific picture of the world. The degree of autonomy of special scientific pictures of the world in the second half of the 20th century has considerably decreased, they are transforming into aspects and fragments of the integral general scientific picture of the world. They realize, each one in its area, the ideas of universal evolutionism.

At first sight, it looks like we are witnessing a reproduction of the situation characteristic for the early stages of development of new European science, when the mechanistic picture of the world, playing the part of a general scientific picture, provided a synthesis of the achievements of science of the 17th and the 18th centuries. But behind exterior similarity there is a deep interior difference. The modern scientific picture of the world is not based on striving for the unification of all spheres of knowledge and their reduction to ontological principles of one discipline, but on the unity of different disciplinary ontologies in diversity. Each of them appears as part of a more complicated whole, and each of them inside itself renders concrete the principles of global evolutionism. But in this case the problem, which was formulated above, is solved in analysis of the functions and the typology of the scientific pictures of the world. We are talking about the historicity of those typologies. It turns out that special pictures of the world as relatively independent form of synthesis of knowledge have not always existed in such a quality. In the age of the becoming of natural science they did not exist. Appearing at the time of the differentiation of science into independent disciplines, they started losing independence and turning into aspects or fragments of the modern general scientific picture of the world. Therefore it doesn´t make sense to argue that special scientific pictures of the world (pictures of the reality studied) exist either as independent forms of knowledge or are only fragments of the whole – the general scientific picture of the world.

It is important to consider answers to such questions within the historical context. Everything depends on to what historical stage of development of science we attribute the corresponding answer. The destiny of disciplinary ontologies is at the same time the destiny of disciplinarily organized science at different stages of its historical evolution. Sometimes the opinion is expressed that one day the strengthening of interdisciplinary connections will lead to a complete disappearance of independent disciplines. This point of view is too extreme. It is a mere extrapolation of today´s situation that is characterized by a considerable growth of the specific weight of interdisciplinary science. But it does not take into account the fact that different spheres of knowledge have their own specificities that cannot be reduced to each other. Besides, we are to take into consideration that the disciplinary organisation of science is determined not only by the features of different objective spheres of investigation, but also by possibilities of forming subjects of scientific activity, the presence of certain limits of "information capacity" of the subject and, consequently, the need to quantize the body of knowledge that must be mastered in order to do scientific search.

The specialization necessary for science still remain, it is not even destroyed by the employment of computerization in scientific activity, because using a certain base of knowledge requires understanding and interpreting it as well as mastering its methods. It most likely seems that future science will combine disciplinary and interdisciplinary investigations. It is quite another matter that their direct and indirect connections can become far more intensive, and the boundary between them less hard. Consequently, the general scientific picture of the world will be comprehended more and more clearly as a global investigation program and as a necessary horizon of the systematization of knowledge.

The intensification of the connections between the different disciplines and the growth of importance of interdisciplinary science as a factor of development of the general scientific picture of the world affect not only cognitive, but also the institutional aspects of modern science. We may ascertain that the modern synthesis of achievements of different sciences is proceeding in conditions, when the role of large complex programs and problem oriented interdisciplinary investigations is increasing.

In his analysis of tendencies of development of science in the first half of the 20th century, V. I. Vernadsky noted that they are classified more in accordance with problems than with subjects. In science of the late 20th century this tendency clearly can be realized, especially in connection with the appearance of complicated, often unique complexes as objects of research. Their studies stipulate joint work of specialists of different profiles. The modern practice of social support and the financing of "high science" is an evidence of the priority of branches that have emerged on the junction of different disciplines. These are, for instance, informatics, ecology and biotechnology, programs of search for energy sources, biomedical research etc. The prestige of such branches and programs of such kind is determined first of all by the modern search for a way out of the global crises that has been caused by the industrial, technogenic development of civilization.

The connection of two types of factors determines the development of the modern scientific picture of the world. Social aims and values, changing the shape of science as a social institution, and intrascientific, cognitive factors act in the same direction: they actualize interdisciplinary connections and interactions. The social sciences actively participate in this process along with the other sciences, since most of the modern trends of research have complicated the developing complexes which include man and his activity as a component.

All this, on the one hand, reinforces the role of the general scientific picture of the world, which provides an integral vision of the complicated development of "anthropomeasured" systems and an understanding of the place of each discipline. On the other hand, it stimulates "exchange processes" between the natural, technical and social sciences, and that in turn accelerates "building bridges" between corresponding special scientific pictures of the world, their inclusion into the general scientific picture of the world as components. At the modern stage, the general scientific picture of the world, based on the principles of global evolutionism, is more and more clearly becoming the ontological foundation of future science, uniting natural sciences and humanities.

8. The Relationship of the Natural Sciences and the Humanities

The old opposition of sciences and humanities has resulted in the conclusion of many scientists that the gap between them is broadening more and more, and finally it can lead to their isolation and, as a consequence, even to the appearance of separate cultures with languages alien to each other (Snow 1971). Actually, for a long time natural science was guided by the cognition of "nature in itself" irrespective of the subject of activity. Its aim was to obtain objectively true knowledge and it didn´t deal with value-meaning structures. The attitude towards the natural world was understood as a monologue. The main activity of scientists was considered to be the uncovering and explanation of the existence of natural connections in the natural world and, by revealing them, the reaching of objectively true knowledge, i.e. to ascertain the laws of nature.

At the same time the humanities were oriented at the comprehension of man, human spirit, and culture. Priority for them consisted in uncovering meaning, they more concentrated on understanding than on explanation. The relationship between subject and object (as any cognitive relation) was not monologue, but dialogue. To obtain knowledge within the humanities, an exterior description was insufficient. Hence one said that the method of the "objective", or "exterior" investigation of society should be combined with the method of its investigation "from inside", from the point of view of humans who have formed social and economic structures and are acting in them (Gurevich 1990: 30-31).

M. M. Bakhtin quite precisely noted these specific features of methodology of the natural scientific and social sciences: "Exact sciences are a monologous form of knowledge: intellect contemplates a thing and speaks about it. Here we can see only one subject – comprehending (contemplating) and speaking (uttering). Intellect is opposed only to a voiceless thing. Any object of knowledge (including man) can be perceived and comprehended as a thing. But the subject as such cannot be perceived and studied as a thing, since, being subject, the researcher cannot, remaining subject, become voiceless, consequently, the adequate cognition of the subject can only be dialogue" (Bakhtin 1980: 383).

It really seemed that an insuperable contradiction arose between the natural sciences and the humanities. Moreover, science did not form an integrating general scientific picture of the world. But nowadays we have a real foundation for the solution of this problem. Sciences and humanities can be integrated on foundation of the principles of global evolutionism, which immanently include the objective study of self-developing systems. The correlation of development of such objects with problems of the place of man in the world (a scientific look at man´s inclusion and actions in the functioning of the overwhelming majority of historically developing systems), introduces new, humanistic meaning into scientific knowledge.

The need to connect cognitive and moral aspects of natural scientific knowledge is more and more clearly understood in natural science itself. An example is the position of representatives of so-called biological structuralism, who are making an attempt to work out a new paradigm in biology. Looking for a foundation, this new paradigm turns not only to "exact" natural science, but also to humanitarian knowledge. Taking into account that biology is closer than any other natural science to the study of the nature of man, representatives of "biological structuralism" to large extent link to their work with hopes for changes in the scientific picture of the world, which would attach a human dimension to it (Karpinskaya 1992: 145-146).

In modern natural scientific cognition, we find new tendencies of man´s attitude to nature. Nature, in the broad sense of the word, is not any longer presented as "dead mechanism", at which human activity is aimed. As Prigogine and Stengers note, "it died, that finite, static and harmonious old world, the Copernican revolution destroyed it, having put the Earth into endless space. Our world is not a silent and uniform world consisting of a watch mechanism...Nature was created not for our sake, and it does not submit to our will...The time for a new alliance has come, such an alliance started a long time ago, but was for a long time unrecognized, i.e. an alliance between human history, human societies, knowledge and the employment of the Nature for our purposes" (Prigogine and Stengers 1981: 296).

To ensure his future, man cannot believe that he has no fundamental restrictions in his attempts to transform nature in accordance with his own needs; he has to adapt his needs according to the requirements put by the nature[4]. All this means that now it is time for the establishment of new relationships between man and nature, not in terms of a monologue, but in terms of a dialogue. In the past these aspects were characteristic for humanitarian knowledge. Now they penetrate very different spheres and become an important principle of scientific analysis.

At the same time ideas and principles, developed in natural scientific knowledge, are gradually penetrating the humanities. The ideas of irreversibility, variability in the process of making decisions, the diversity of possible lines of development which appear at a system´s bifurcation points, an organic connection of self-regulation and cooperative effects, etc. – ideas that have been justified in synergetics –, turn out to be significant for the development of the humanities. Constructing various conceptions of the development of society, studying man and his consciousness, they cannot any longer ignore these methodological regulations, which are now developing a general scientific character. When science covers complicated, developing, "anthropomeasured" systems, the formerly insuperable boundaries between the methodology of the natural sciencies and the humanities disappear.

We may conclude that, having started the research of "anthropomeasured objects", the sciences are coming closer to "the object field" of research in the humanities. In this respect we can remind the reader of Karl Marx´s well-known statement that "history itself is a *real* part of *natural history* – of nature developing into man. Natural science will in time incorporate into itself the science of man, just as the science of man will incorporate into itself natural science: there will be *one* science" (Marx 1844: 543).

Thus, in the late 20th century a fundamentally new tendency in scientific knowledge has emerged. It has led to a reconstruction of the general scientific picture of the world as an integral system of nature, man and society. This system of notions, forming on the foundation of the principles of global evolutionism, is becoming a fundamental investigation program of science at the stage of an intensive interdisciplinary synthesis of knowledge. Absorbing the totality of fundamental scientific results and synthesizing them within the integral image of the development of the Universe, living nature, man and society, the modern scientific picture of the world actively communicates with cultural worldview universalities, in the context of which its development takes place. On the one

[4] Such states of the attitude concerning the relationship of man-nature are called ´ecological imperative´ by Nikita Moiseev (Moiseev 1990: 40).

hand, it adapts to them, but on the other hand, it introduces radical novelty into established cultural mentalities.

The development of the modern scientific picture of the world is one of the aspects in the search for new worldviews and responses to the historical challenge that modern civilization is facing.

9. The Scientific Picture of the World as a Reference Point for New Worldviews on the Development of Civilization

Modern science is developing and functioning in a special historical epoch. Its general cultural meaning is determined by the inclusion into the choice of strategies of humanity and the search for new ways of development of civilization. Such as search is needed due to to crises of the late 20th century, which have led to the emergence of modern global problems. Their comprehension requires us to re-evaluate the development of technogenic civilization that has existed for four centuries. Doubt is now cast on many of its values that were connected with a special attitude towards nature, man, understanding of activity etc. and that seemed to be an unshakeable condition of progress.

At our time the technogenic civilization, developing as a kind of antipode to traditional societies, has approached the "bifurcation point" after which a transition to a qualitatively new state may follow. What direction the system will choose, what character its development will have, the status of science in society, and also the very existence of humanity – all these questions depend on the direction of development of society.

The culture of the technogenic civilization has always included scientific rationality as its basic value. Within this culture the scientific picture of the world developed and functioned. In the technogenic civilization the employment of science was first of all connected with the technological transformation of the object world. The scientific picture of the world orientated man not only in understanding the world, but also in transforming activity, aimed at its change.
In fact, from the 17th century until nowadays new European culture has been regulated by this paradigm, according to which man should actualize his creative abilities by directing his activity outwards, at the transformation of the world and first of all at nature.

An attitude to nature that saw it as opposed to man was characteristic for the worldview that was connected to the science of the New Age. V. I. Vernadsky wrote: "Copernicus, Kepler, Galileo, Newton in a few decades broke the connection between man and the Universe established in ages... The scientific picture of the Universe, expressed by Newton´s laws, did not leave room for any display of life. Not only man, not only all living matter, but our whole planet were lost in the infinity of Cosmos" (Vernadsky 1940: 176).

The idea of a demarcation between the world of man and the world of nature that was presented as alien to man, was immanently included in the scientific picture of the world and for a long time served as worldview foundation of its historical development.

This idea found justification in many values of the technogenic civilization, in particular, it correlated with those interpretations of Christianity, which gradually gained dominance in culture beginning with the period of Reformation. This variant of Christianity not only assumed a dualism of man and nature, but also insisted on the postulate that it is God´s will that man should exploit nature to suit his own ends (White 1967). It gave psychological confidence in man´s striving for transforming nature without considering the importance of the preservation of natural objects. Thus it advanced the exploitation of nature (White 1967).

This attitude turned into the dominant value of the technogenic culture. A scientist, acting within this cultural tradition and guided by some scientific picture of the world, realized himself as an active creator of the new, eliciting nature´s laws in order to extend the possibilities to bend nature to people´s needs. The civilization oriented at such type of scientific rationality, achieved indubitable successes: the ideas of progress, democracy, freedom and personal initiative were established in it (Kara-Murza 1990: 3-15). It provided constant growth of productivity and improvement of the quality of people´s life. But when global problems of humanity emerged in the 20th century, the doubts have arosen about the correctness of the choice of developmental paths in the Western (technogenic) civilization and, as a consequence, of the adequacy of the underlying worldviews and ideals.

The search for new ways of development of civilization is now confronted also with the problem of intercultural dialogue and the formation of a new type of rationality. In this respect it is important to consider the place and role of the picture of the world in the search for new worldviews and orientations that can provide the possibility for humanity to survive. These questions can be formulated in the following way: does the modern scientific picture of the world require any system of values and worldview structures, fundamentally different in comparison with previous stages of development of science, for its justification? Did this picture cause a radical transformation of the worldview foundations of scientific cognition? What can be its concrete contribution to worldviews that concern the requirements of the new stage of development of civilization, have to deal with a solution of global crises and have to provide strategies of survival and further development of humanity?

In the modern situation of society there is the formation of a new view of the natural environment. It is now considered not as a conglomeration of isolated objects, not as a mechanical system, but as an integral living organism that can be changed only within certain limits. A violation of these limits leads to a change of the system, its transition into a qualitatively new state that is able to cause irreversible destruction of the system´s integrity. At previous stages of development of science, since the establishment of natural science until the middle of the 20th century, such an "organismic" understanding of the surrounding nature would have been perceived as an atavism, as return to half-mythological consciousness that is not coordinated with the ideas and principles of the scientific picture of the world. But after the notion of living nature as a complex interaction of ecosystems had been formed and had entered science and after modern ecology had developed, such an understanding became a scientific principle, justified by numerous theories and facts. Ecological knowledge plays a special part in forming scientific system that are concerned with the sphere of natural processes with which man interacts in his activity and which is his immediate habitat as a biological species. This system of notions forms an important entity that combines knowledge about the biosphere on the one hand and knowledge about social processes on the other hand. It serves as a sort of bridge between the notions of the development of living nature and the development of human society. So it is not surprising that ecological knowledge is getting special importance in solving problems that concern the interactions of man and nature, the overcoming of the ecological crisis, and hence it is becoming an important factor in forming new worldview foundations of science.

At the same time the principles, developed in ecology and included into the general scientific picture of the world, are also getting wider worldview character. They exert influence upon the worldviews of the whole culture, they "essentially affect the spiritual and intellectual climate of the modern epoch at the whole and determine the transformation of the value structures of thinking" (Zelenkov and Vodopianov 1987: 81). In modern culture we find more and more clearly shaped contours of the new vision of the world, and the scientific picture of the world makes a considerable contribution to its establisment. This vision is based on the idea of an interconnection and harmonious relationships between people, man and nature, which constitute a single whole.

Within such an approach we can trace the establishment of a new vision of man as an organic part of nature, not as its lord; science develops the ideas of the priority of cooperation over competition (Laszlo 1990: 23-31).

E. Laszlo speaks of the world that in respect to the "new vision" is absorbing the achievements of modern science. F. Capra´s ideas of a "united ecological vision of the world" are in line with such an approach. Capra uses this notion in the meaning of a "profound ecology", this concept is opposed to a "superficial ecology" that is anthropocentric by nature, regards man as towering above nature, sees in him the source of values, assigning nature the role of an auxiliary means (Capra 1990: 33). Unlike the "superficial ecology", the "profound ecology" in Capra´s opinion does not posit man above his natural environment, but interprets the world as an integral totality of phenomena connected with and dependent on each other. It is oriented at the consideration of value of all living beings, and man is regarded as regular and integral part in the whole diversity of life (Capra 1990: 33).

Ecology and, in particular, "united ecology" (A. Ness) demonstrates evidently the scantiness of anthropocentrism, proving that "man is neither lord, nor centre of the Universe, he is only a being that submits to the laws of reciprocity" (Macey 1990: 82). Changes in science correlate with an intense search for new worldviews. There is a search for a new ideologies, rethinking old ones, as e.g. in the works of R. Attfield and L. White (Attfield 1983), the creation of "new ethics" as suggested by E. Laszlo and O. Leopold. Laszlo says that we need a new morality that is more based on the necessary requirement of humanity adaptating as a global system to its surrounding natural environment, than on individual values. Such ethics can be created on the foundation of the ideal of respect towards natural systems (Laszlo1972: 281).

Similar ideas have been developed by Leopold who proposes to see ethics from the philosophical point of view as distinction of social and antisocial behaviour and ethics from the ecological point of view as restriction of the freedom of action in the struggle for existence (Leopold 1983). Leopold´s new ethics is a type of ethics that determines man´s relations with the Earth, animals and plants. In his opinion, it should change man´s role, converting the conqueror of community into one member of the community that is ordinary and equal in rights to the other members. Ethics of the Earth reflects the existence of ecological conscience and, correspondingly, individual responsibility in preservation of the Earth. Humanity is facing the goal of forming an ethical attitude concerning the Earth, which cannot exist without the veneration of Earth´s values (Leopold 1983).

These ideas can be expressed with A. Schweitzer´s conception of the veneration for life as a foundation of an ethical world. For him the idea of veneration for life is an answer to the question of how man and the world are correlated with each other. He notes the dual character of the relationship between man and the world, taking into consideration that man bears both passive and active relations to the world: on the one hand, man has to submit to the natural course of events, in accordance of which he builds up his life, on the other hand, he has the possibilities to exert influence upon life and its change within certain limits. And the only way to attach meaning to human existence is to consciously reflect the natural connection with the world (Schweitzer1990:339). These speculations of the prominent philosopher and scientist are principles of his so- called biosphere ethics that includes not only interrelations between people, but also interrelations between man and nature. It contains "veneration for the high (celestial world), compassion to the equal (human world), aid to the low (plant and animal world)" (Shipunov 1990: 450).

The new worldview connects modern science with the other spheres of creative cultural work. Mutual influences of these spheres accelerate the process of formation of new meanings of cultural universalities and, correspondingly, new value systems that stipulate a way to other, non-traditional strategies of vital human functions. In turn, new senses and values to a larger and larger extent are included into the system of philosophical and worldview foundations of science. The key moments in their development are the notions of the organic involvement of man into the integral cosmos and of the proportionality of man to the world which engenderes him (due to cosmic evolution).

Ethical ideas of man´s responsibility for nature make the picture of the world axiologically loaded. Considering man in his connection with the rest of the world, regarding the world as an organic integrity, is an important methodological reference-point that is able to lead to a change the traditional view of technogenic civilization that concerns the destination of man and his activity. New worldviews concerning the attitude towards nature – based on ethics, rejecting the principle of supremacy over nature and including the idea of man´s responsibility –, in turn pave the way to a new understanding of rationality as dialogue between man and the world.

The principles of openness and self-regulation of complicated systems, developed in synergetics and introduced as an important principle into the modern scientific picture of the world, have lead to the same philosophical ideas and worldviews. As Prigogine and Stengers note, "natural sciences nowadays display a need for dialogue with the open world. The time for a new concord has come, concord started long ago, but for a long time unrecognized, between human history, human societies, knowledge and using Nature for our purposes" (Prigogine and Stengers 1981: 273, 296). Comprehending the world, man should not thrust his own language on nature, but enter dialogue with it. In Prigogine´s opinion, modern science has learned how to treat nature with respect, hence nature cannot be described "from the outside". Description of nature is an alive dialogue, communication, and it submits to limitations that are evidences that we are macroscopic beings, immersed into the real physical world (Prigogine and Stengers 1984). Dialogue with nature in the new type of rationality can be achieved by the ideal of the openness of consciousness to the diversity of approaches. Interaction (communication) of individual minds and mentalities of different cultures should be encouraged.

This aspect of openness and communication as characteristic for the new type of rationality and corresponding strategies of activity are especially emphasized by J. Habermas. He notes that "instead of relying on reason of the productive forces, i. e. finally on reason of natural science and technology, I trust the productive force of communication" (Habermas 1992: 85). The frameworks and structures of communication, shared activity, openness are continuously changing – both "in themselves and in relation to other spheres of society as such" (Habermas 1992: 181). The ontology of this new type of rationality is based on the notion of the integral cosmos, which organically includes man, and on the notion of the objects of reality as historically developing "anthropomeasured" systems possessing "synergetic" properties. These ideas, concretized in the modern scientific picture of the world, lead to a new consideration of subject and object of cognition, which are now not regarded as alien to each other, but are presented as only relatively autonomous components of a special integral, historically developing system built into the world. In this approach rationality is already endowed with new distinctive features. It is characterized by openness, a reflexive explication of value and meaning structures included in mechanisms and results of the objectively true comprehension of the world.

"Open rationality" (V. S. Shvyrev) is now opposed to closed rationality and intraparadigmatic rationalit where a scientist is moving only within an adopted, rigid conceptual framework. Open rationality assumes an "attentive and respectful attitude towards alternative pictures of the world, appearing in cultural and worldview conditions different from those of modern science, it assumes dialogue and mutual enrichment of different, but equal in rights cognitive positions" (Shvyrev1992:98). From this point of view, we have to pay special attention to new and unusual properties of the modern scientific picture of the world. In many aspects it embodies the ideals of open rationality, and its worldview correlatse with philosophical and ideological ideas and values that stem from different, in many respects even opposite cultures.

10. New Rationality and Russian Cosmism

There is a correspondence of the modern scientific picture of the world not only to those mentalities that have been gradually formed within the Western (technogenic) culture of the late 20th century, but also a correspondence to philosophical ideas that have grown on the soil of Russian culture and its Silver Age, as well as to the philosophical outlooks and worldviews of traditional cultures of the East. Up to now, the scientific picture of the world has developed based on the mentalities of the technogenic culture. When other types of cultures adopted science, they were required to transfer certain fragments of Western experience to different ground. Such transferations have always transformed traditional culture and were realized in the course of modernizations that aimed at the transition of traditional societies to technogenic development (for example, Peter the Great´s reforms in Russia). The process of transferring science to Russia in Peter´s epoch is a characteristic example. It became possible only along with the adoption of fragments of urban culture, European education, a new way of life, which Peter the Great often put through by force (Kuznetsova 1982).

A quite tight connection of new European science with mentalities characteristic for the technogenic culture led to a fundamental mismatch of the scientific picture of the world, its philosophical and worldview foundations, on the one hand, and prescientific cosmologies of traditional societies, on the other hand. Scientific knowledge in traditional cultures that are based on myths and religious worldviews didn´t play a role in the formation of ethical ideas. A different situation can be found in the technogenic civilization. Here scientific rationality was conceived as the justifying principle of social, ethical and religious worldviews (an example is neo-Thomist philosophy). It is no surprise that the distinctive opposition between the Western technogenic culture and the culture of traditional societies first of all was displayed by the opposition of the scientific picture of the world and its philosophical corollaries to "organismic" notions of the world that could be found in traditional oriental cultures. But such opposition hardly can be found in respect to modern science. The changes that took place there in the late 20th formed a new picture that has resulted in special philosophical and methodological corollaries. These corollaries are corresponding to Eastern cultural ideas and have a lot in common with original philosophical Russian ideas.

We would like to discuss the latter situation especially because we today have to face the problem of dialogue between different cultures and cultural interchange of ideas that is fundamentally important for modern civilizational development. First, let us pay attention to the coincidence of many notions of the modern scientific picture of the world with the philosophical ideas of Russian "cosmism". These ideas for a long time were seen as some kind of periphery of the world of philosophical thought, though they certainly exerted influence upon works of such prominent natural scientists such as V. I. Vernadsky. Traditionally in Russian cosmism at least three trends can be distinguished: the natural scientific one (N. A. Umov, N. G. Kholodny, V. I. Vernadsky, K. E. Tsiolkovsky, A. L. Chizhevsky); the religious-philosophical one (N. F. Fedorov); and the poetical one (S. P. Dyachkov, V. F. Odoevsky, A. V. Sukhovo-Kobylin) (Guirenock 1960: 5).

Russian cosmism appeared as sort of antithesis to the classical physicalist paradigm of thinking that was based on strict a differentiation of man and nature. It made an attempt to revive the ontology of an integral vision that organically unites man and cosmos. These problems were discussed both in the scientific and the religious form of cosmism. In the religious form N. Fedorov´s conception was the most significant one. Like other cosmists, he was not satisfied with the split of the Universe into man and nature as opposed entities. Such an opposition, in his opinion, condemned nature to thoughtlessness and destructiveness, and man to submission to the existing "evil world". Fedorov maintained the ideas of a unity of man and nature, a connection between "soul" and cosmos in terms of regulation and resurrection. He offered a project of resurrection that was not understood only as a resurrection of ancestors, but contained at least two aspects: raising from the dead in a narrow, direct sense, and in a wider, metaphoric sense that includes nature´s ability of self-reconstruction (Fedorov 1982). Fedorov´s resurrection project was connected with the idea of the human mind´s going to outer space. For him, "the Earth is not bound", and "human activity cannot be restricted by the limits of the terrestrial planet", which is only the starting point of this activity. One should critically look at the Utopian and fantastic elements of N. Fedorov´s views, which contain a considerable grain of mysticism, but nevertheless there are important rational moments of his conception: the quite clearly expressed idea of interconnection, the unity of man and cosmos, the idea of the correlation of the rational and moral elements of man, the ideal of the unity of humanity as planetary community of people.

But while religious cosmism was more notable for the fantastic and speculative character of its discourses, the natural scientific trend, solving the problem of interconnection between man and cosmos, paid special attention to the comprehension of scientific achievements that confirmed that interconnection. N.

G. Kholodny developed these ideas in terms of anthropocosmism, opposing it to anthropocentrism. He wrote: "Having put himself in the place of God, man destroyed his natural connections with nature and condemned himself to a long solitary existence" (Kholodny 1982: 187). In Kholodny´s opinion, anthropocentrism passed through several stages in its development: at the first stage man did not oppose himself to nature and did not oppose it, he rather "humanized" the natural forces. At the second stage man, extracting himself from nature, man looks at it as the object for research, the base of his well-being. At the next stage man uplifts himself over nature, basing himself in this activity on spiritual forces he studies the Universe. And, lastly, the next stage is characterized by a crisis of the anthropocentric worldview, which starts to collapse under the influence of the achievements of science and philosophy (Kholodny 1982: 175). N. G. Kholodny was right noting that in the past anthropocentrism had played a positive role; it freed man from his fright at nature by means of uplifting him over the latter. But gradually, beside anthropocentrism there appeared sprouts of the new vision – anthropocosmism. Kholodny regarded anthropocosmism as a certain line of development of the human intellect, will and feelings, which led people to their aims. An essential element in anthropocosmism was the attempt to reconsider the question of man´s place in nature and of his interrelations with cosmos on the foundation of natural scientific knowledge.

Anthropocosmism started to consider man as one of the organic parts of the world and assumed that only such thinking can be the key to understanding the nature of man. Man should strive for unity with nature, which enriches and broadens his inner life (Kholodny 1982: 178-197). N. A. Umov developed similar ideas, emphasizing that "man can understand himself as a part, one of the transient links of the Universe". He also believed that the anthropocentric worldview was running into ruin, making place for anthropocosmism (Umov 1916: 215). The idea of the interconnection of man and cosmos was especially emphasized in K. E. Tsiolkovsky´s works, one of which was even entitled "Cosmic Philosophy". He wrote: "All of the cosmos conditions our life... Everything is continuous and everything is united" (Tsiolkovsky 1986: 302, 278). "The Universe would be meaningless if it were not filled with an organic, intelligent, feeling world" (Tsiolkovsky1986: 378). We can see a certain concord of Tsiolkovsky´s ideas with the anthropic principle that was formulated later. Tsiolkovsky not merely points at the interconnection of man and cosmos, but stresses the dependence of the former on the latter. "... It is hard to suppose that any part of it (cosmos) will not exert, sooner or later, influence upon us" (Tsiolkovsky 1986: 302). This idea – influence of both nearer and far space upon human life – was at length analyzed by A. L. Chizhevsky, who believed that "our scientific worldview is still far from a historical notion of the role of space radiations for the organic realm" (Chizhevsky

1976: 27). But the number of advances of 20th century science in Chizhevsky opinion allows to conclude that “in the science on nature an idea of the unity and coherence of all phenomena in the world and the appreciation of the world as undivided whole become nowadays especially clear and deep … The structure of the Earth, its physics and chemistry, the biosphere are a penetration of the structure and mechanics of the Universe” (Chizhevsky 1976: 24, 26). Chizhevsky opposed his point of view to the existing opinion that "life is a result of a random game of only terrestrial forces". For him, to a considerably large extent life is a more cosmic than a terrestrial phenomenon. It was created by the influence of the creative dynamics of space upon the inert material of the Earth. He noted that man "is not only a terrestrial being, but a cosmicone that is connected by all his biology, all molecules, particles of the body with space, with the latter´s rays, flows and fields" (Chizhevsky 1976: 33, 331). In this sense the influence of solar energy upon the course of life processes does not seem to be accidental. Chizhevsky was one of the first scientists who justified this theory by concrete scientific facts. In particular, he analyzed correlations between solar activity and peaks of epidemic diseases and demonstrated that solar activity plays the part of some kind of regulator of the course of the epidemic processes. Certainly, this does not mean that "the state of solar activity is the direct reason of an epidemic spread of certain diseases", but the activity of the Sun "favours their fast ripening and intensive course" (Chizhevsky 1976: 246).

In the scientific tradition of Russian cosmism the problem of a united world and united knowledge of the world was elaborated in the most significant form by V. I. Vernadsky. As well as other cosmists, Vernadsky supposed that the "anthropocentric notion does not coincide with the real reveal of the cosmos, which is enveloped by scientific work and scientific thought that deals with the investigation of nature" (Vernadsky 1978: 40). He noted that "science still has no clear understanding that phenomena of life and phenomena of dead nature, seen from a geological, i. e. planetary point of view, are displays of a united process" (Vernadsky 1978: 12). But, as Vernadsky emphasized, biologists should not forget that they study the living world that is an integral part of the Earth´s crust, exerts active reverse influence upon it and transforms it. They should not consider life as out of touch with the evolution of the integral cosmos. In his opinion, such a direction was caused by the fact that for a long time the Universe had seemed to be lifeless. The basis for such statements was the establishment of Copernicus´ principle in science. When in the first half of the 19th century scientists gathered numeric data about the size of the Universe, it seemed like life was entirely dissolved into space, and gradually the opinion was advanced that inconsiderable meaning of life is the proper conclusion from scientific investigations. But, as science developed, reasons appeared that cast doubt on the indisputability of such conclusions (Vernadsky 1978: 31-33).

Vernadsky, like other cosmists, has a point of view that is different from the traditional position. He demonstrated that in the worldly evolution life is not something random, but a regular consequence, that the character of cosmic development of life processes is conditioned by the cosmic whole. In such a consideration life is now presented as a cosmic phenomenon (Vernadsky 1978: 43,36). V. I. Vernadsky regards humanity as the part of biosphere that exerts active influence upon this system. Human consciousness, emerging in the course of bioevolution, becomes a special factor of evolution, whose meaning grows in time. The developing of the biosphere into a noosphere is the logical completion of the evolution of matter: all parts of the developing world turn out as being interconnected, and man fits into this world.

Russian cosmism quite clearly understood not only man´s dependence on the cosmos, but also (what is especially important) man´s reverse influences upon the surrounding world. In Russian cosmism, the commensurability of man and the rest of the world was a foundation for the development of the idea of a need to commeasure human activity with the principles of integrity of this world. Russian cosmism justified the principles of man´s new attitude towards nature. In fact, it understood the problems that were later called ´global problems´. At least, the idea of a possible ecological crisis, although in hidden form, can be found quite clearly in the expressed words of the representatives of this trend. It is no mere chance that N. G. Kholodny emphasized that the "transformations imposed on nature by man have their limits" Kholodny (1982: 142). As a reasonable being, man should foresee the results of his activity, for which he bears responsibility. Russian cosmism´s intuitive understanding of the global contradictions between man´s technocratic activity and the harmony of the cosmos resulted a search for possible ways out of unfavourable states that might confront humanity in future times.

Practically each of the cosmists offered an own version of humanity´s future development. K. E. Tsiolkovsky painted a quite idyllic picture: "... climate will be changed at the will of need. All Earth will become inhabited and will yield great fruits. There will be a total scope for the development of both human social and individual qualities. The technology of the future will give people the chance to study all planets... imperfect worlds will be destroyed and replaced by new populations. The Earth will give heavenly colonies its surplus of people... Finally, we will see an infinite Universe with an infinite number of perfect beings" (Tsiolkovsky (1986: 287-290). V. I. Vernadsky painted a more realistic scenario in his conception. The consideration of man as a special geological force, able to transform the world where he lives radically, led to the conclusion that possible negative consequences of human activit could arise. This can be seen as prevision of possible global ecological crises. At the same time, Vernadsky was optimistic when he looked at the perspective of humanity, connecting its future with the processes of the transition from the biosphere to the noosphere and to the growth of the regulating role of human reason.

Original speculations, anticipating the modern situation of global crises, were offered in N. Fedorov´s philosophy of "common deed". The thinker brilliantly cautioned about unreasonably treating nature and possible consequences. "People have, most likely, done all the harm they could concerning nature (exhaustion, devastation, spoiling), and concerning each other (invention of deadly weapons, means of mutual annihilation)" (Fedorov 1982: 55). All evil of our life, in Fedorov´s opinion, proceeds from a disharmony of man and nature. Having drawn a quite bright picture of "all-Earth crisis", he offered his project of solving the problem by the way of "the common deed". This common deed is presented as a regulation of spontaneous natural forces. "In regulation, in ruling the forces of blind nature consists that great deed, which can and must become common" (Fedorov 1982: 58-59). In realization of his project Fedorov mostly relied on man´s moral forces and the force of his reason. He wrote: "Cosmos needs reason to be cosmos, not chaos. Cosmos (as it is, but not as it must be) is a force without reason, while man is (yet) a reason without force. But how can reason become force, and force become reason? Force will become reasonable when reason rules it. So, everything depends on man" (Fedorov 1982: 535). In N. Fedorov´s conception "the common deed" was presented as the way that on a humanistic, moral foundation leads to unity and renovation.

Thus, the cosmist philosophy quite clearly brought out two aspects of the interconnection of man and space: on the one hand, man is presented as a fragment of evolving cosmos, its integral part, in all its revelations dependent on the cosmic whole. On the other hand, man himself was regarded as a factor of evolution, developing his abilities in such a way that creating new technics and technology, he started exerting active influence upon the surrounding world. Although in the late 19th until the early 20th centuries the belief in scientific and technical progress was very evident, and the crisis consequences of the technocratic attitude to the world were not displayed yet, cosmists warned future generations of possible negative consequences of an unrestrained, limitless technological exploitation of nature. But still cosmism, although it contained original ideas and possessed a considerable prognostic power, wasn´t spread very widely. In fact, it repeated the destiny of many philosophical conceptions, whose productive ideas greatly outstripped their time. But in today´s situation, when humanity is facing ecological crisis, the search for "common deed" as the regulation of the relations between man and nature is gaining priority.

We may state that cosmism as a special branch of philosophical thought that is in line with the modern striving for new senses of life, new ideals, and the harmonization of man and nature. We especially emphasize the coincidence of the main principles of cosmist philosophy and many fundamental ideas of the modern scientific picture of the world and its worldview conclusions. Cosmism returns us to the integral vision of the world as unity of man and cosmos. It is able to play a positive role in the synthesis of ideas developed in the Western European cultural tradition and in oriental philosophical systems, where man from the very beginning has been considered as an integral part of cosmos. Correspondingly, the ideas of cosmism are organically included into working out new metaphysics that could be the philosophical foundation of the post-non-classical stage of development of science. In this respects notions that belong to global evolutionism such as "anthropomeasured", historically developing systems and the ideals of "anthropocosmism" are important.

11. New Rationality and Eastern Philosophy

The open character of the modern scientific picture of the world reveals its commensurability not only with the principles of Russian cosmism, but also with many worldview worked out in the traditional cultures of the East. Ideas of synergetics and global evolutionism can also be found in and have been anticipated by oriental philosophy that for a long time wasn´t adequate perceived in the European cultural tradition. First of all it refers to the world as a united organism, different parts of which are in distinctive resonance to each other. This ontology is based immanently on the ideal of a harmony of man and nature as well as their inner unity. Striving for unity found its expression in the statement "one in all and all in one" that was the dominant principle of taoism and confucianism (Grigorieva 1979: 119). In Buddhism it is expressed in the doctrine of dharma. "All elements of dharma are something homogenous and equal in force; they all are connected with each other" (Rosenberg 1991: 128). Characteristic for cultures of the East, in particular for the Old Chinese philosophical doctrines, is the notion of the world as an enormous living organism. It was seen not as dually divided into natural and human worlds, but was perceived as an organic whole, all parts of which are correlatively connected and exert influence upon each other. This cosmology excluded an opposition of subject and object and was based on the adoption of a binary nature of things corresponding to the Yin-Yang model (Grigorieva 1979: 106-112, 148). Yin and Yang represented two primary forces that express the bipolarity of existence: Yin acted as the negative pole, which embodied the passive element, and Yang as the positive, active, creative element. Being interconnected as light and darkness, Yin and Jang permanently alternate and interact with each other.

The conception of Yin and Yang was based on the understanding of a universal interconnection of phenomena and their mutual resonance. “Everything is penetrated by the united way – tao, everything is interconnected. Life is united, and striving of every part of it should coincide with striving of the whole” (*Ancient Chinese Philosophy* 1972: 26). Man, included in the world, should feel the world rhythm, bring his mind into accord with the “celestial rhythm”, and then he will be able to grasp the nature of things and hear the “music of humanity” (Grigorieva 1983: 127). The very idea of rhythms of the world, their influences upon each other, including rhythms of human vital functions in the process of this interaction, was for a long time perceived by the European mind as something without a serious foundation in scientific facts, as something mystical and irrational. But in the modern scientific picture of the world that integrates the achievements of synergetics, new notions concerning the interaction of the parts and the whole and of the concordance of their changes are formed. It has been elucidated that unforced interactions, based on cooperative effects, start playing a special role in complicated systems.

For open, self-organizing systems such interactions are the constituting factor. Thanks to them the system is able to pass from one state of self-organisation to another, creating new structures in the process of their evolution. Cooperative properties are traced in very different self-regulating systems, which consist of a very large number of elements and subsystems. They can be found for instance in the behaviour of plasma, in coherent laser radiation, in morphogenesis and the dynamics of populations, in economic processes of self-regulating markets (Haken 1987). For example, at a certain critical level of pumping energy into a laser, the effect of the emission of a light wave by atoms emerges emerges: the atoms act in a strictly correlated way, each atom emits a purely sinusoidal wave, as if coordinating its behaviour with the behaviour of another emitting atom, i. e. the effect of self-organisation emerges here (Haken 1987). Similar effects can be observed in processes of embryonic cell division, when each cell in the tissue receives information of its situation from surrounding cells, and so their mutually coordinated differentiation takes place (Haken 1987). In the experiments on embryos a cell of the central part of the body, after transplantation into the head, developed into an eye. These experiments demonstrated that cells do not dispose of information of their further development from the very beginning (for instance, through DNA), but extract it from its position in the cellular tissue (Haken 1987).

Synergetics generalizes similar situations of cooperative effects of elements and subsystems in complicated self-organizing systems. It regards the “resonance” of functioning parts in such systems and the presence of cooperative effects as an important display of self-cooperation. If we turn again from these positions to the ideas of oriental philosophies about the “resonance” of different parts of the united cosmic whole, these ideas will obtain new meaning: in any case, they can be perceived as a worldview that anticipated and finds response in the modern notions of the scientific picture of the world that makes use of the “synergetic” approach in order to describe the various processes of nature and social life. There are more parallels between the cosmological notions of the traditional oriental cultures and the ideas of synergetics that form a part of the modern scientific picture of the world. In traditional worldview systems of the East a special role belonged to the idea of non-being, which was perceived as all completeness of the world. Non-being was interpreted as reality, wherefrom situations of being (objects, processes, phenomena) emerge, submitting to a strict rhythm of the worldly development, and then, having exhausted themselves, return to non-being (Grigorieva 1979).

It is very interesting to compare these ideas with the fundamental synergetic notion of the appearance of structures in a non-linear medium. The non-linear medium as potentially possible field of structures, where they appear and disappear, is a special kind of reality that gives birth to the given structures. If we imagine an infinite number of potentially possible structures in an infinitely complicated non-linear medium, there is an analogy to non-being (with respect to already emerged and disappeared structures) containing all the future completeness of the world. Old oriental notions of the world as an integral organism, in which man is included, of resonance between different parts of this organism, formed an ideal of human activity that is different from the one of the Western technogenic culture.

The understanding of man as demiurge, who forcefully transforms objects in order to bend them to his will, was alien to oriental cultures. As H. Hesse stressed, people growing up with the traditions of these cultures set themselves the same aim as Western people – to know how to rule the laws of nature, but they choose an entirely different ways. They didn´t think that they oppose nature and did not try to intrude by force into its mysteries, they never opposed themselves to nature and were not hostile to it, they always remained a part of it and showed reverential love for it (Hesse1970). The Chinese cultural traditional taught that human activity towards nature should not bear the character of violence. As J. Needham noted, within this tradition force was always hardly recognized as a way of action. In Chinese culture man was associated with the image of a peasant, not that of a sailor or cattle-breeder (who are believed to be inclined to command and submission). “But the peasant-farmer, once he has done all that is necessary for the crops, must wait for them to come up. A famous parable in Chinese philosophical literature derides a man of Sung State who was discontented with the growth rate of his plants and started to pull at them to help them to come up" (Needham 1964: 135).

In Chinese doctrines, the opposition of violent and nonviolent action was developed in the terms "Wei" and "Wu-Wei"(application of force and non-action). Non-action (wu-wei) did not mean the absence of any action, but a kind of action that lets nature develop in its own way. "A perfectly wise, doing deeds, prefers non-action. Realization of non-action always brings calmness" (*Ancient Chinese Philosophy* (1972: 115-116). It is indicative, that the "Wu-Wei" principle, rejecting the way of action based on permanent force and intrusion into the course of natural processes, in our age unexpectedly correlates with the ideas of synergetics as possible strategies for regulating complicated self-organizing systems. For instance, it becomes clear that such a system, undergoing influences from violent and active forces and pressures from the outside, probably will not give rise to new states and new structures, but will "decline" to old structures. But if it passes a bifurcation point, then a little energetic "influence-prick" in the proper time-space locus is enough to make the system reorganize, and new type of structures will appear (Kurdyumov 1990).

We have noted above that man´s interaction with complex open systems goes on in such a way that human action itself is not something exterior, but appears to be included into the system, transforming every time the field of possible state. Hence, it becomes important for active strategies and intervention to determine thresholds of interference in proceeding processes and provide, by means of minimized influence, those directions of development of the system, which lets it avoid catastrophic consequences and achieve people´s goals. The "Wu-Wei" principle was oriented at quite similar behaviour and strategies of human activity. It required that people should feel the natural rhythms of the natural world and should act in accordance with them, letting nature itself disclose its interior potentials and choose ways of development of processes, which would be coordinated with human needs. Old Chinese philosophy stressed that only people "ignorant of the true laws of being" understand the "Wu-Wei" principle as absence of action, obedience and submissiveness. "Non-action" did not mean absence of action, but natural action, which corresponded to the nature of things (Grigorieva 1983: 128).

In discussing the ideals of human activity it is important to distinguish one more extremely significant aspect that can be found in oriental doctrines and has a lot in common with the modern search for new values and human strategies in complexity. We mean an interconnection between morality and truth that has always been the proclaimed aim of scientific knowledge. The question of their correlation has been permanently discussed in Western philosophy, but it was solved the following way: the process of comprehending the truth by itself was supposed to be a moral action.

The scientific revolution in Europe, as J. Needham noted, isolated scientific truth from ethics, and the world became more dangerous, whereas the oriental doctrines never knew such an isolation (Needham 1988). They developed a more delicate treatment of the relation between truth and morality. From the point of view of sages of the East, true knowledge consists not in the investigation of objects with the aim to take possession of them, but in reaching co-being with the world (Grigorieva 1979:75). One can comprehend a thing only by following the Tao way, regarded as natural way of things and at the same time as a moral way that one should travel. Tao opens only for moral people, and it is the only way that can lead people to perfection (*Ancient Chinese Philosophy* 1972, Vol.1: 114, 119-121, 128). In order to approach the the truth, one needs moral self-training. People´s activity directed at the cognition of the exterior world, and their activity directed at the perfection of their interior world, should be coordinated and cannot exist without one another.

One of the oldest and most fundamental ideas of Chinese philosophy is the idea of the cosmic importance of man´s moral qualities. Thinking about the resonance of all parts of the cosmos, Chinese sages believed that "it is man´s behaviour, his morality that the order in cosmos, regular change of seasons, heat and cold depends on" (Grigorieva (1979: 112). The way, in the image of Tao, or Heaven, regulates people´s actions. But Heaven "can turn to man, and it can turn out from him". It is no mere chance that the Chinese say: "Heaven acts in dependence on people´s deeds". In Old China natural calamities were perceived as evidences of untrue ruling, as indicators if an immoral behaviour of sovereigns (Grigorieva 1979: 113). Certainly, if we understand these ideas literally, they will sound very mystically. But they also contain a more profound, rational meaning that is connected to the demand of ethically regulating people´s cognitive and technological activity (including the technology of social management). In this more profound meaning, these ideas are quite consonant with the modern search for reference points for worldviews on the development of civilization.

Thus, in the late 20th century, when humanity faces the problem of choosing between different strategies of survival, many ideas worked out in traditional oriental philosophies correlate with new values and new worldviews that appear within the modern technogenic culture and are formed in different spheres of this culture, including science. The development of the modern scientific picture of the world justifies new methods of cognition of the world that are consonant with the forgotten achievements of traditional cultures as worldview corollaries. We may ascertain that the development of the modern scientific picture of the world is organically included in the processes of the formation of a new type of planetary thinking that is based on tolerance and dialogue of cultures and connected with a search for a way out of the modern global crises.

As open paradigm the scientific picture of the world contributes to intercultural understanding. It unites new approaches that emerged within the scientific rationality characteristic for the technogenic (Western) civilization, with ideas worked out within an entirely different cultural tradition, in oriental philosophy and Russian ´cosmic philosophy´. The modern scientific picture of the world is itself included into the dialogue of cultures, whose development has up to now passed as if along parallel lines. It is becoming one of the most important factors of a cross-cultural interaction between the West and the East.

References:

Advances of Physical Sciences 144, Ser.2. Moscow (in Russian)

Ancient Chinese Philosophy (1972), Moscow, in Russian.

Attfield, Richard (1983)*The Ethics of Environmental Concern*, New York: Columbia Univ. Press.

Bakhtin, Mikhail (1980) *Esthetics of Verbal Creativity*, Moscow. (in Russian)

Calvin, Michael (1971) *Chemical Evolution* Moscow (in Russian)

Capra, Fritiof (1989) *Uncommon Wisdom. Conversations with Remarkable People.* Toronto-N.Y.

Carter, Brand (1974) *Large Number Coincidences and the Anthropic Principle in Cosmology.* In: *Confrontation of Cosmological Theories with Observational Data*, ed. M. Longair, Reidel, Dordrect.

Chizhevsky, Alexander (1976) *An Earthy Echo of the Solar Storms*, Moscow. (in Russian).

Dobronravova, Irina (1991) *Synergetics: becoming of non-linear thought.* Kiev, (in Russian).

Fedorov, Nikolai (1982) *Collected Works.* Moscow. (in Russian).

Friedman, Alexander (1965) *World as a Space and Time.* Moscow (in Russian).

Glensdorff, Peter and Prigogine, Ilya (1971) *Thermodynamic theory of structure, stability and fluctuations*, N.Y.: Wiley-Interscience.

Grigorieva, Tatyana (1979) *Japanese Artistic Tradition*, Moscow. (in Russian).

Grigorieva, Tatyana (1983) *Japanese XXth Century Literature*, Moscow. (in Russian).

Guirenock, Fedor (1960) *Russian Cosmists*, Moscow. (in Russian).

Gurevich, Aron (1990) *Social History and Historical Science*. In: *Voprosy filosofii,* Vol. 4. (in Russian)

Guth, Alex and Steinhardt, Peter (1984) *The Inflationary Universe.* In: *Scientific American*, May 1984.

Habermas, Jurgen (1992) *Democracy. Reason. Morality* Translations from German and English of lectures delivered in the Institute of Philosophy of the Russian Academy of Sciences in April 1989 in Moscow (in Russian).

Haken, Herman (1987). *Advanced Synergetics*, Springer Ser. Synergetics, Vol. 20. 2nd corr. Printing, Berlin,
Heidelberg: Springer

Hesse, Herman (1970) *Das Glasperlenspiel*, In: *Gessamelte Werke*, Bd.1-12, Fr./M.

Jantsch, Erich (1980) *The Self-organizing Universe: Science and Human Implication of the Emerging Paradigm of Evolution*, Oxford.

Kara-Murza, Sergei (1990) *Science and Crisis of Civilization.* In: *Voprosy filosofii,* Vol. 9 (in Russian).

Karpinskaya, Regina (1992) *Biology, Ideals of Sciene and Mankind´s Destiny.* In: *Voprosy Filosofii,* Vol. 11. (in Russian).

Kazyutinsky, Vadim (1989)*Universe in the Scientific Picture of the World and social-practical activity of Mankind*, In: *Philosophy, Natural Science, Social developments*. Moscow. (in Russian)

Kazyutinsky, Vadim (1986) *Conception of Global Evolutionism in the Scientific Picture of the World.* In: *On Modern Status of an Idea of Global Evolutionism.* Moscow. (in Russian)

Kholodny, Nikolai (1982) *Selected Works*, Kiev. (in Russian).

Klimontovich, Nikolai (1986) *On Synergetics without Formulas*, Minsk (in Russian).

Kurdyumov, Sergei (1990) *Evolution Laws and Self-Organisation of Complex Systems*, Moscow. (in Russian).

Kuznetsova, Natalya (1982) *Science and its History*, Moscow. (in Russian).

Laszlo, Erwin (1972) *Introduction to System Philosophy*, New York.

Laszlo, Erwin (1990) *A new understanding of the evolution. Introduction to the global epoch*. In: *One world for everybody*, Moscow. (in Russian).

Leopold, O. (1983) *A Sand County Almanac.* New York: Ballantine Books.

Linde, Andrei (1984) *The Inflationary Universe.* In: *Advances of Physical Sciences* 144, Ser.2 (in Russian)

Marx, Karl (1844) *Economic and Philosophical Manuscripts*. In: MEW, Vol. 42. Berlin. Dietz.

Moiseev, Nikita (1986) *Strategy of Reason.* In: *Znanie-Sila,* vol.10 (in Russian)

Moiseev, Nikita (1989) *Logics of Universal Evolutionism and Cooperativity.* In: *Voprosy Filosofii* vol. 8 (in Russian)

Moiseev, Nikita (1990) *Man in the Universe and on the Earth*, In: *Voprosy Filosofii, Vol* 6.

Needham, George (1964) *Society and Science in East and West*, In: *The Science of Science. Society in the Technological Age*, Ed. by. M. Goldsmith and A. Mackay, London, Toronto: Souvenir Press.

Needham, George (1988) *Precursors of Modern Science*, In: *UNESCO Courier*, November.

Prigogine, Ilya and Stengers, Isabelle (1981) *La Nouvelle alliance: Metamorphose de la science*, Paris.

Prigogine, Ilya and Stengers, Isabelle (1984) *Order out of Chaos. Man´s New Dialogue with Nature*. Foreword by A.Toffler, New York-Toronto: Bantam Books.

Rosenberg, O. (1991) *Works on Buddhism*, Moscow. (in Russian).

Rudenko, A. (1987) *Chemical Evolution and Biogenesis*. In: *Philosophy and Sociology of Science and Technics. Annual bulletin*, Moscow (in Russian).

Schweitzer, A. (1990) *Veneration for Life* Moscow. (in Russian).

Shipunov, Fedor (1990) *Biosphere Ethics*, In: *Ecological Alternative*, Moscow. (in Russian).

Shvyrev, Vladimir (1992) *Rationality as a Culture Value*. In: *Voprosy Filosofii,* Vol 6. (in Rusian).

Silk, George (1982) *Big Bang: Birth and Evolution of the Universe.* Moscow

Snow, Charles (1971) *The Two Cultures.* In: *New Statesman*, 6 October, 1956, Public Affairs, Macmillan, London.

Stepin, Vyacheslav and Kuznetsova, Lidia (1994) *Scientific Picture of the World in the Culture of Technogenic Civilization*.

Toffler, Olwin (1986) *Science and Change.* Preface to: Prigogine, Stengers. *Order out of Chaos*. Moscow (in Russian).

Tsiolkovsky, Konstantin (1986) *Dreams on Earth and Heaven*, Tula. (in Russian).

Umov, Nikolai (1916) *Collected works* Vol.3, Moscow.

Vernadsky, Vladimir (1934) *Issues of Biogeochemistry*, Moscow (in Russian).

Vernadsky, Vladimir (1940) *Biogeochemical Essays*, Moscow-Leningrad. (in Russian).

Vernadsky, Vladimir (1944) *A Few Words on the Noosphere*. In: *Advances of Modern Biology*, Vol.XVIII, Ser.2. (in Russian).

Vernadsky, Vladimir (1977) *Reflections of a Naturalist. Scientific Thought as the Planetary Phenomenon*, Moscow. (in Russian).

Vernadsky, Vladimir (1978) *Living Substance*, Moscow. (in Russian).

Vodopianov, Peter (1981) *Stability and Dynamics of Biosphere*, Minsk. (in Russian)

White, Lesley (1967) *The Historical Roots of Our Ecologic Crisis*. In: *Science*, 155 (3767), 10 March 1967, 1203-1207.

Zelenkov, A. and Vodopianov, P. (1987) *Biosphere Dynamics and Sociocultural Traditions* Minsk. (in Russian).

A New Way of Thinking and a New World View. On the Philosophy of Self-Organisation I[*]

Wolfgang Hofkirchner

The context in which all strategies for human action are formulated today fundamentally distinguishes itself from that of earlier times. We live in an age of global problems.

The impressions made by the atom bomb, industrial and agricultural catastrophes, hunger, suffering and death in the poor parts of the world, have raised consciousness of the destructive and fallible nature of the human technosphere, the fragile and finite nature of the human ecosphere, and the unsettled, unbalanced nature of the human sociosphere.

The global problems are problems concerning the survival of humanity: first, they concern humanity as a whole (as object); second, they can also only be solved by humanity as a whole (as subject).

Assuming that these problems have an anthropogenous origin in the use of technical, natural and human resources of social systems, human efforts to cope with them are purposeful.

In a sense, every action performed by a social subject, be it a nation state, societal institutions, or a single human, may be measured by what it contributes towards the alleviation or aggravation of the global challenges facing us.

Co-operation in meeting the global challenges presupposes communication of ends and means between all affected and communication, in turn, presupposes the recognition of the threat, its causes and possible solutions by all individual minds involved.

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Producing and implementing strategies for dealing with the *global problematique* is a collective endeavour – so to say, an act of collective intelligence – that requires new ways of thinking and new world views.

A paradigm shift as far-reaching as never seen before is under way. It is about to change the nature of science and technology.

As it is in the nature of the challenges to be global, they have to be approached in a similarly global fashion. The split into disciplines which are both alien and deaf to each other is an obstacle for consistent comprehension, which takes into consideration as many of the manifold aspects as are necessary in order to take measures to reach the desired goals without being frustrated by undesired effects. The urge, however, to transcend the borders of the disciplines, the trend towards transdisciplinarity, and the search for a base of understanding between the domains of science, has been growing.

What is known as sciences of complexity, theories of dynamic, open, non-linear systems, second-order cybernetics, self-organisation theories, is an element, if not the core, of this overall shift. This thinking in complexity cuts across the natural and social sciences.

According to this thinking, all science serves to support efforts to master the global challenges. According to it, more and more researchers discover evolutionary systems no matter what real-world object they may be investigating, for the provision of specialised knowledge about the functioning of different self-organising systems is essential to influence them in such a way as to trigger the most promising development paths. Finally, according to it, diverse methodological approaches are less and less viewed as impediments that endanger the unity of science; rather, they are increasingly regarded as useful means towards the same end and as an enrichment of science as long as the common basis of the different methods is not violated.

The basis of this shift concerns ways of thinking as well as world views.

Ways of Thinking

Ways of thinking can be seen as ways of considering how to relate identity and difference, how to relate the one and the many, how to relate unity and diversity. This question seems to be the most fundamental question you can conceive of while having in mind that thinking can be defined as an operation of identifying the one among the diversity and differentiating the many within the unity.

There are, in terms of ideal types, several ways conceivable:

- one establishes identity by eliminating the difference (unification);
- another eliminates identity by establishing the difference (diversification);
- a last one establishes identity in a line with the difference (integration).

Regarding the establishment of identity by the elimination of the difference, the question arises as to how the unification comes about, that is, how the less differentiated problems or objects or phenomena do relate to more differentiated ones. Taking two possible answers into consideration, we can finally distinguish between four ways of thinking:

- a first one that establishes identity by eliminating the difference for the benefit of the less differentiated side of the difference; it reduces the side with the higher degree of differentiation to the side with the lower degree of differentiation; this is known as reductionism (A); it yields “unity without diversity”;
- a second one that establishes identity by eliminating the difference for the benefit of the more differentiated side of the difference; it takes the higher degree of differentiation as its point of departure and extrapolates or projects from there to the lower degree of differentiation; it is the opposite of reductionism (A) and might be called “the projection perspective” (B); it too yields “unity without diversity”;
- a third one that eliminates identity by establishing the difference for the sake of any side of the difference; it abandons all relationships between all of them by treating them as disjunctive; it is opposed to reductionism (A) as well as to the projection perspective (B) and could be called “the disjunction perspective” (C); it yields “diversity without unity”;
- a fourth one that establishes identity as well as difference favouring neither of the sides of the difference, rather attaching to each side the significance due to it; it integrates the lower and the higher degree of differentiation by establishing a relationship between them that, in particular, might be characterized by the following criteria: firstly, both sides of the relation are opposed to each other; secondly, they depend on each other; thirdly, they are asymmetrical. When all these criteria are met the relationship is usually called “dialectic” (Hofkirchner 1998). This approach opposes reductionism (A), the projecton perspective (B), as well as the disjunction one (C). It will be called “the integration perspective” (D). It yields “unity in diversity”.

World Views

The most fundamental implications of ideas whatsoever, insofar as they go beyond being judgements on a particular matter that forms only a single part of the world to express an attitude towards the world as a whole, are called world views (in the sense of the German "Weltanschauung"). Theorised world views, that is, world views theoretically reflected, represent philosophy.

A world view has three dimensions:

- one refers to reasoning and the employment of instruments to gain knowledge; the question answered here is "By which means do we explain and/or understand the world?"; philosophical disciplines like epistemology and methodology and logic are dealing with that; this dimension may be called "approaching the world" (1);
- another one refers to assumptions about the order of the real world; the question put here runs "Is the world ordered by necessity and/or is it ordered by chance?"; that is what ontology is about; this dimension may be called "archetyping the world", because it yields certain mental archetypes of the world (2);
- a last one refers to the devising of guidelines for action; the question belonging to the domains of ethics, axiology, praxeology is "Can we actualise the virtual and/or virtualise the actual?", the actual being the world as it is and the virtual being the world as we envision it; thus, this dimension is called "(en)visioning the world" which produces visions (3).

These three dimensions are interlinked in the following way: a specific approach (1) is consistent with a certain variety of archetypes (2) but excludes particular archetypes and a specific archetype is consistent with a certain variety of visions (3) but excludes particular visions; a vision (3) can be based upon one certain archetype (2) only, and an archetype (2) upon one certain approach (1) only.

Ways of Thinking in World Views

The next step is to cross-table ways of thinking and world views and identify the paradigms that have grown obsolete inasmuch as they have proven counterproductive in respect to the global challenges and the paradigm that promises humankind remedy (see table 1).

		Explaining vs. Understanding	Presupposing Necessity vs. Chance	Actualising vs. Virtualising
Unifying	Reducing	Naturalistic Rationalism	Materialistic Determinism	Modern Activism
	Projecting	Culturalistic Rationalism	Idealistic Determinism	Antimodern Activism
Diversifying		Culturalistic Irrationalism	Idealistic Indeterminism	Antimodern Passivism
Integrating		Reflexive Rationalism	Less-than-strict Determinism	Responsible Activism

Tab. 1: Ways of thinking and world view dimensions

The traditional cluster of ways of thinking and world views is characterised by the divide of rationalism and irrationalism, determinism and indeterminism, activism and passivism. Each of the divides prolongs an unresolved contradiction between the prevailing occidental scientific thought called the “classical” paradigm here, on the one hand, and submerged humane feeling called “nonclassical” paradigm here, on the other, that in vain has attempted to compensate for the deficiencies of the first (see Toulmin 1990).

The, so to speak, “postnonclassical” paradigm[1] tries to do justice to both of the strands while overcoming their one-sidedness by promoting the idea of the unity of methods, reality, and practice.

In detail.

A Fresh Perspective on Comprehension

Naturalism and culturalistic rationalism revolve around one basic method of explanation and prediction on which all rational methods of comprehension are deemed to converge (see table 2).

[1] I borrow the wordings “classical”–“nonclassical”–“postnonclassical” from V. Stepin who introduced them to the scientific community some ten years ago, albeit in Russian (personal communication, I. Dobronravova; cf. also Stepin´s article in this book). I admit that my wordings may have a different meaning.

From the Rationalism–Irrationalism Divide...	to an Integrative View
<u>Principle of Complete Deducibility (Deductive Rationalism) vs. Nondeducibility (Irrationalism):</u> ANALYSIS vs. SYNTHESIS (Causal Explanation/Prediction vs. "Verstehen")	<u>Principle of Investigating into the Proximate Necessary Condition (Reflexive Rationalism):</u> INFERENCE IN JUMPS (Dialectic of History and Logic: Ascendence from the Potential to the Actual and from the Abstract to the Concrete)

Tab. 2: The paradigm shift from deductivism and irrationalism to dialectical reasoning

Speaking in terms of formal logic, an explanation or prediction is the deduction of a conclusion from premises such that the conclusion describes what is to be explained or predicted, and that the premises are made up of descriptions of what together is expected to do the explaining or predicting. After Hempel and Oppenheim this scheme is called deductive-nomological, if it couples empirical and theoretical knowledge by subsuming facts (empirical) under some law (theoretical) that covers those facts.

Given a universal implication as a first premise, which represents the covering law, and an instantiation of its conditional component as second premise, which represents specific conditions not spelled out in the covering law, the application of the rule of *modus ponens* implies an instantiation of the consequence of the law as a conclusion which represents just that final condition which was or will be observed. The conclusion must be realised when the premises are the case. *Per definitionem* the truth is transferred from the premises to the conclusion.

Naturalistic deductivism assumes an extra-human, physicalistic or biologistic way to look. In any case, it reduces phenomena of a higher degree of differentiation in the conclusions to phenomena of a lower degree of differentiation in the premises.

Culturalistic deductivism takes the human being as given. This leads to anthropomorphic subsumptions. Thus, the premises of the argument are made to contain projections of human conditions, that is, projections from phenomena of a higher degree of differentiation onto phenomena of a lower degree of differentiation.

Naturalistic and culturalistic deductivism hold that all phenomena can be explained and predicted likewise. But this is not always so. Because there are cases in which such explanations and predictions do not work – and the reason why they do not work is not ignorance, that is, missing observations or missing hypotheses, but overlooking of the differentiation between necessary conditions and sufficient conditions –, a so-called two-cultures thinking tries to find the solution in a different way of understanding (German "Verstehen") which is a central term in the tradition of phenomenology and hermeneutics. It offers a quite different option and postulates a quite different approach of comprehension which is distinct from the "nomothetic" way: an "idiographic" way. Sectors of reality that can not be explained shall be described and interpreted according to some sense. Since this sense can be any one, this touch of arbitrariness leaves this two-cultures thinking open to criticism for lacking of rational substantiation of its background ideas.

According to the method of explanation and prediction preferred, deductivism stresses analysis by means of dissection as appropriate method of recognition. Non-deductive culturalism, on the contrary, has a rather synthetic approach.

Summing up, naturalism and culturalistic rationalism can be characterised by the principle of complete deducibility and the irrational two-cultures thinking by the principle of nondeducibility.

To accept this contradictory state of the art would mean to forego the commonalities of differing methods. A fresh look is needed to get out of the trap.

In contrast to the view imposed by rationalism, it is not unscientific to get by without deductive methods; and in contrast to the dualistic culturalism, it is not sensible to divide the applicability of scientific methods along the line dictated by the differentiation of nomothetic and idiographic. Both the rational and irrational philosophies are concerned with the description of events and the comprehension of their arising, be this in the form of explanation, prediction or understanding. Such comprehension is achieved when a demonstration of those conditions succeeds, to which a participatory role can be attributed at the onset of the events. Sometimes, such conditions may constrain to precisely one case. The onset of events is then a sequence, which happens out of necessity. What happens out of necessity must of course be possible. Other times, the conditions may constrain to a number of cases. The sequence of events is then a process that implies chance elements, but which would be made impossible in the absence of the conditions.

The appropriate conditions may thus be described as necessary conditions, which create the possibility of all conceivable cases.

Thus, that immediate necessary condition is sought that makes possible what shall be comprehended. Having found it, explanation and prediction, as a rule, remain incomplete. There is a leap from potentiality to actuality which can only be covered if the necessary condition does at the same time suffice, that is, the condition is also sufficient.

Acknowledging historicity, as a maxim, means, accordingly, showing the preconditions of what evolves by showing the possibility of the real. That is, it has to be demonstrated that in the case of comprehending something actual the *status quo ante* includes the actual as a potential or in the case of forecasting the *status quo* includes something to come as a potential implicit in the original actual.

Acknowledging logicity, as another maxim, means to ascend from the abstract to the concrete, which is no deduction in the formal logical sense. Step by step the reproduction of the object of comprehension is enriched with newly added specifications.

Thus, we have an inference in jumps.

In contrast to the "classical" resp. "nonclassical" approach whose leitmotif is looking for the "necessary and sufficient condition" resp. looking for anything else because there is "no condition at all", the "postnonclassical" principle is the search for the "necessary, but not in all cases sufficient condition." This principle will allow reconciliation of the classical and nonclassical methods.

A Fresh Perspective on our Real World

Determinism is the ideal toward which mainstream thinking in the (natural and social) sciences tends. This is materialism in that it denies ideal causes. All phenomena are explained by reducing effects to causes that are sufficient to produce those effects. If cause and effect are related in such a way that each cause is related to one, and only one, effect, determinism is held to be complete (see Heylighen 1990). This view is considered to be that of strict determinism (see Table 3).

From the Determinism–Indeterminism Divide...	to an Integrative View
Principle of Complete Determinacy vs. Indeterminacy: COSMOS vs. CHAOS (Preformationism/Merism resp. Teleologism/Holism vs. Dualism)	Principle of Assuming Real-World Propensities (Less-than-strict Determinism): CHAOSMOS (Subject-Object-Dialectic: Ascendence from the Old to the New and from the Parts to the Whole)

Tab. 3: The paradigm shift from strict determinism and indeterminism to assuming weak determination

Strict determinism assumes that the causal relations in the universe are as compellingly interconnected as are the logical relations in our minds.

In strictly determined events, mechanisms are said to be at work that necessitate the transformation of particular causes into particular effects. Here *causa aequat effectum* or *actio est reactio* – as Newton´s dictum may be interpreted (Fleissner and Hofkirchner 1997). Popper (1972) called this a clockwork view of the universe which the Demon of Laplace is likely to fancy. It takes the original meaning of the term "cosmos" seriously: total order.

As to the diachronous character of the world, the new is completely determined by the old so that there is nothing new at all. Accordingly, "e-volution" is understood as the unwrapping of something that is already there before it is unwrapped. Preformationists claim just that.

As to the synchronous character of the world, the whole is completely determined by its parts. There is no whole that is "more than the sum" of its parts. The world is explained by summarising all its parts. This may be called merism (e.g., atomism).

The opposite of the materialistic view is idealistic determinism. This determinism may be as strict as that of materialism; the difference is that the causes do have an idealistic element. Some of the humanities tend to be biased this way.

Evolution of whatever is said to evolve seems to be strictly governed by a *telos* that determines current developments by future. It is a pull-model, in contrary to the push-model of materialism. This is known as teleology.

Moreover, wholes seem to exert a strong pressure by way of downward causation on their parts. This is called holism.

The opposite of both materialistic and idealistic determinism is dualistic indeterminism. It denies that effects are caused and holds that therefore there is no sense in ascribing cause-effect-roles to events or entities. From this perspective the world is heterogeneous, fragmented and disintegrated, and it falls apart in disjunctive sets. Dualism overlooks continua and is neglectful of the old and of parts which dichotomises old and new as well as parts and wholes. Old and new do not depend on each other; neither do parts and wholes. Evolution is as undetermined and history as arbitrary as the order and the logic of the structure: it is chaos, total disorder. Becoming and being is like with “clouds” (as Popper put it) which are unpredictable and irreducible.

The unity of reality, however, can be envisaged by recognising that deterministic events are but a special case of events in the universe. Deterministic events occur with objects only. In the case of subjects, events are not strictly determined, the effect is not predictable because it is a kind of subject that intervenes in the chain of cause and effect and introduces a degree of freedom that cannot be forced into a single alternative.

It is not only humans who display subjectivity. The making of something subject to oneself which makes oneself a subject undergoes a process of unfolding so as to let us distinguish between different types of subjects in the universe according to the degree of subjectivity they manifest. The minimal unit of subjectivity is a something that is provided with a minimal quantum of degrees of freedom to act. This something is the most rudimentary and most primitive subject. It differs fundamentally from being an object, that is, something that does not dispose of options to act.

An object which has no options available strictly acts according to the Aristotelian *causa efficiens* and *causa materialis*, while a subject´s act does include *causa finalis* and *causa formalis* as well, for there is some end toward which the subject directs its action and there is some form which the subject implements through acting. End and form are options at the disposal of the subject. They are selected out of a plural of options which make up the degrees of freedom.

Thus, *causa non aequat effectum*, *actio non est reactio*. This is neither strict determinism nor indeterminism, but a less than strict determinism. It attributes cause-effect-roles, but does so without coupling them unambiguously so as to let causes have different effects or to let effects have different causes (see again Heylighen 1990).

Subject-object-dialectic paints a new picture of the world: it is neither cosmos nor chaos, but bears features of both; it is "chaosmos" – a term coined by the French philosopher Edgar Morin (1998).

Regarding the aspect of becoming, the universe and its constituents are considered open in the sense that future is not predestinate. The old is only the necessary condition for the new, i.e. the new cannot come into existence unless the old provides the preconditions for the start of the new. But the new is not completely determined by the old. There is a degree of freedom in the new that cannot be reduced to components of the old.

Regarding the aspect of being, the entities of the universe form a layered structure in which the entities that arose in later stages of the evolution process are found on higher levels, the older entities on lower levels. The parts are only the necessary condition for the whole, that is, without parts there is no whole, but the parts alone do not necessitate the existence of the whole. The whole, being not completely determined by its parts, does in turn not completely determine its parts. An irreducible degree of freedom resides in the whole as well as in the parts.

Thus, contrary to the strict determinism of materialism and idealism and contrary to the indeterminism of dualism, ontologically, the core of the "postnonclassical" paradigm is the principle of less-than-strict determinism which can be characterised by the assumption of "propensities" rather than eternal "laws" or the lack of any regularities. This is an idea of late Popper (1997). The motto is neither "same results from same conditions" nor "bolts from the blue", but "great oaks from little acorns."

A Fresh Perspective on Strategies

Modernism is the ideology of modernity. Modernity is that age of history of humankind in which a particular type of civilisational development is said to predominate. This mode of civilisation has its roots in the Christian-occidental mode of science and technology whose innovations are seen as the driving force of society. Today, the western type of science and technology, the related industrial and computerised takeover of the natural world, and the resulting uniform culture of capitalism, democracy and human rights are the main features of modernity.

The conviction of modernism is that progress in science and technology is automatically translated into progress in society. Thus everything that can be made shall be allowed for. That´s practicism. That´s the reduction of the virtual (that which is desirable) to the actual (that which turns out possible).

This modernist view may be traced back to the Bible. It can be called "dominionism", because it aims at erecting a dominion over the world we live in. It is an optimistic view for those who are in power: it implies that everything can be managed, steered, planned, that is to say, everything can be controlled totally, if there is the will to do that (see Table 4).

From the Activism–Passivism Divide...	to an Integrative View
Principle of Complete Controllability (Totalitarian Activism) vs. Uncontrollability (Passivism): EXPENSIVE INTERVENTIONS (Practicism – Belief in Progress – resp. Wishful Thinking) vs. NONINTERVENTION	Principle of Piecemeal Engineering (Responsible Activism): CHANGING THE WORLD BY OBSERVING ITS LAWS INCLUDING THE LAW OF UNINTENDED CONSEQUENCES (Dialectic of the Feasible and the Desirable: Ascendence from the Less Good to the Better)

Tab. 4: The paradigm shift from dominionism and passivism to a precautionary guiding of action

Interventions aim at producing final states which are desired by functionalising cause-effect relationships in that way that the causes equal the initial states from which you depart and the effects equal the desired states at which you will arrive. Interventions are operations linearly sequenced.

Interventions may be expensive in that the means used is not as efficient though they are effective in that they yield the desired result. But it may be a big effort to put the means at work. And the means may yield undesired results, too.

Anti-Modernism in the form of wishful thinking can be characterised by the same totalitarian activist belief in intervening in the world. It can be said to differ from modernism only in emphasising the final cause, for it prioritises values, ethics and morals opposite to those of modernity. For wishful thinking there is no such thing that is not capable of being made. The virtual is projected onto the actual. It comes in two varieties: utopianism and romanticism. The first is looking forward, oriented towards a future that leaves behind modernity, while the second is looking back, oriented towards premodern states of the past.

Anti-Modernism in the form of the ideology of postmodernity, refuses interventions at all. From the experience of modernity being confronted with all the undesired results – side-effects in other domains of our world, local and far-distance effects, and short- and long-term effects – which are detrimental to our survival it concludes the imperative of non-intervention: the world is taboo. Nature, Creation, fellow humans are treated as inviolable.

Hence, the principle of complete controllability resp. the principle of uncontrollability are typical of modernism and wishful thinking resp. postmodernism.

Both principles, however, are counterproductive. They do not assure the unity of practice. They do not show a way of how to get a grip on the complex and global problems.

On the one hand, carrying on along the path of modernity cannot make itself plausible (in the way that a simple increase in science and technology with the same economic drives and political framework conditions could bring about a qualitatively changed situation), if the present situation is in debt to a lower quantity of the same development. In this conservative variant, continuity is made absolute and the necessity or possibility of a jump in quality is denied. Either the solving of global problems is seen as something with which, in the framework of the modern age, can be coped with, without needing any modifications of civilisation´s development, or the existing situation is attributed with a problem-solving capacity on a vastly different scale, because obstacles are not recognised. In neither case is there a need for action.

On the other hand, the call for a U-turn would throw the baby out with the bathwater if it proposed something radically different here and now, without consideration of development so far. It believes it would have to do without any modern science or technology, just as it would have to forego modern economy and politics. This nihilism makes discontinuity absolute, and denies the possibility or necessity of the continuation of certain relationship structures in societal development, it dualises the bad reality and desired good to the point that every possible course of action becomes superfluous.

Apart from these two alternatives, there is a way out that stresses the possibility and necessity of both discontinuity and continuity in the scientific-technical development which is enclosed in the societal one. Eventually, after centuries of predominance of the modern, Western-controlled (natural) sciences, a paradigm change is on the way. However, this new view does not need to, indeed must not, be a return to pre-modern contemplation.

The global problems have their cause, finally, in socio-political developments, but they are accelerated by scientific technological progress, and they can also only be brought towards a solution when social and technological changes are interconnected. Science and technology can do justice to their original purpose – to alleviate human life and generally make that life more pleasant – only when they are no longer left to pursue their seeming natural course. Instead of being left to their own dynamics, they should be deliberately put into operation after appropriate reflection and careful consideration, and should be managed with conscious control, i.e., when their programme is executed with respect to the ideals of the survival of humanity in a future in which it is worth living, and when a constant control of the results of the implementation of the programme is instituted. That means, that science must devote careful consideration to its technological consequences in society, must anticipate possible desired or undesired effects, and must carry out any appropriate readjustments or reorientations.

This may be considered the principle of piecemeal engineering as coined by Popper. Taking into account that reality is something that inheres propensities and therefore is something contingent, piecemeal engineering is prepared to observe the law of unintended consequences at least to the same degree as it tries to observe any other law in order to change the world according to the dictum of Francis Bacon. So, it is not complete control and it is not no control over subject-similar entities, it is a kind of smart, fuzzy, indirect control instead. It sets the stage for ascending from the less good to the better. It reconciles the feasible with the desired. That´s responsible activism.

Objects of Action, of Reality and of Consideration

Having dealt with the paradigm shift from the reductionistic, projective and disjunctive way of thinking to the integrative one in all three dimensions of the world view, it is worth underlining the close relationship between the dimensions within each paradigm.

Let us distinguish between objects of action, of reality and of consideration. Objects of action (O_a) are the ones which are acted upon. Objects of reality (O_r) are the ones existing as such. And objects of consideration (O_c) are the ones in our heads. Eventually, they are identical.

And let O_x^1 and O_x^2 indicate either the same object at two different points of time or two different objects at the same time and let the arrow indicate a linear transformation and the broken arrow a transformation involving ambiguity.

According to the way we (think to) act on objects, we fancy how they exist independently of our actions. And according to the way (we think) the objects exist, we apply methods of investigation and representation to them.

And according to the way we (think to) link objects in action, (we think) they are able to be linked in reality, and according to the latter (we think) they have to be linked in our cconsiderations.

Now, the paradigm which is to be overcome can be characterised in the following way (see Figure 1): given dominionism, the action is a brute force operation which leads from one object to another like an inital state leads to a well-determined final state which is the desired one; this corresponds to reality, given strict determinism, in which one object is connected to another like a cause that is connected to its necessary effect; this, finally, corresponds to consideration, given deductivism, for which one object necessitates the other like premises that necessitate the conclusion in a compelling inference.

Contrary to that, the “nonclassical” paradigm cuts all connections (see Figure 2): there is no operation at all that leads to a desired state, there is no necessity at all that leads to an effect, and there is no inference at all that leads to a conclusion.

The “postnonclassical” paradigm may be characterised as follows (see Figure 3): the objects of consideration are coupled in a dialectical manner, the first one representing the necessary condition for the second, and the second representing a new quality (dialectic of history and logic); this corresponds to the first object of reality being the base for the second one that is created in a contingent way like the subject-object dialectic suggests (necessity and chance together); this, finally, corresponds to objects of action that, in a dialectic of the feasible and the desirable, are constantly evaluated while they are operated on.

Thus, strategies in the new millennium have to be based upon the real-world implications and comprehension implications of the new way of thinking and new world view.

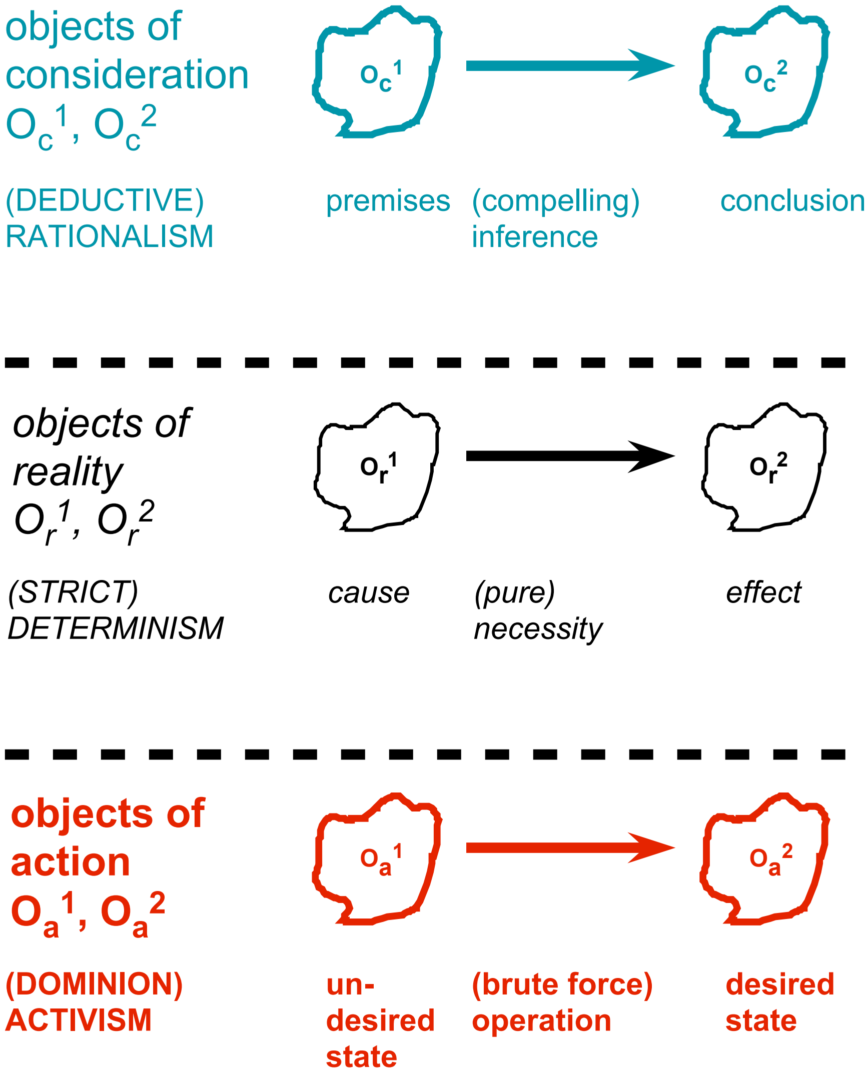

Fig. 1: Objects of consideration, reality and action according to the classical paradigm

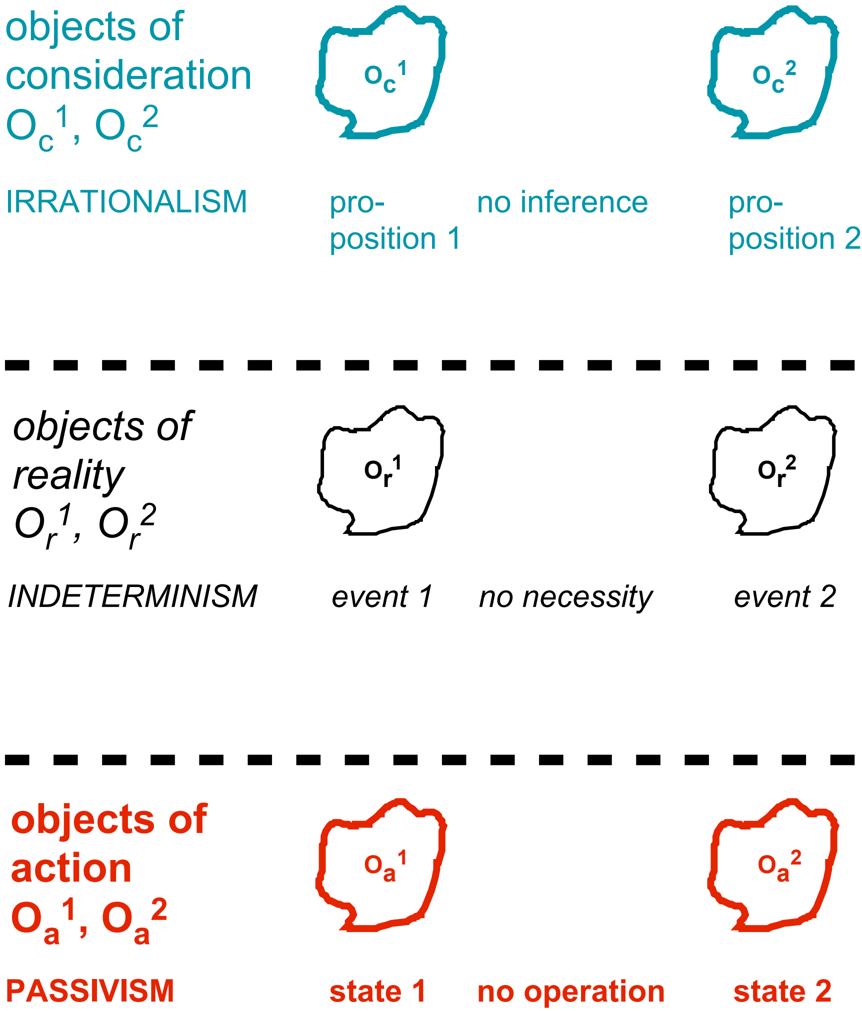

Fig. 2: Objects of consideration, reality and action according to the nonclassical paradigm

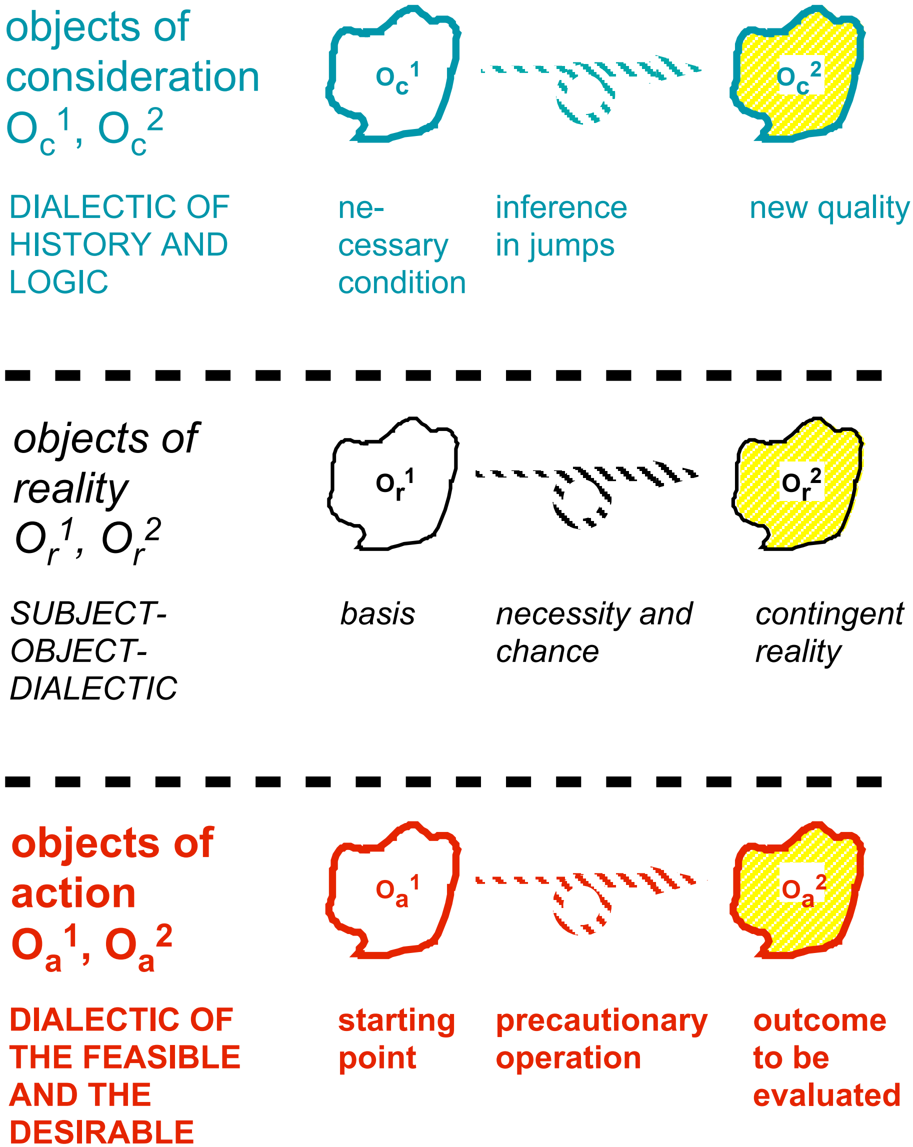

Fig. 3: Objects of consideration, reality and action according to the postnonclassical paradigm

References:

Fleissner, P./Hofkirchner, W. (1997) *Actio non est reactio. An extension of the concept of causality towards phenomena of information*. In: World Futures 49/50, 3-4/1-4, 409-427.

Heylighen, F. (1990) *Autonomy and Cognition as the Maintenance and Processing of Distinctions*. In: Heylighen, F./Rosseel, E./Demeyere, F. (Eds.) (1990) *Self-Steering and Cognition in Complex Systems, Toward a New Cybernetics*. New York. Gordon & Breach, pp. 89-106.

Hofkirchner, W. (1998) *Emergence and the Logic of Explanation. An Argument for the Unity of Science*. In: Acta Polytechnica Scandinavica, Mathematics, Computing and Management in Engineering Series 91, pp. 23-30.

Hofkirchner, W. (1999) *Ways of Thinking and the Unification of Science*. In: Allen, J.K./Hall, M.L.W./Wilby, J. (Eds.) (1999) Proceedings of the 43rd Annual Conference of ISSS (The International Society for the Systems Sciences). ISBN 09664183-2-8 (CD-ROM).

Hofkirchner, W. (2001) *The hidden ontology. Real-world evolutionary systems concept as key to information science*. In: Emergence 3.3, pp. 22-41.

Morin, E. (1998) *Homeland Earth. A Manifesto for the New Millennium*. Cresskill, NJ. Hampton Press.

Popper, K.R. (1972) *Objektive Knowledge.* Oxford. Clarendon Press.

Popper, K.R. (1997) *A World of Propensities*. Bristol. Thoemmes Press.

Toulmin, S. (1990) *Cosmopolis. The hidden agenda of modernity*. New York. Free Press.

Fundamental Properties of Self-Organisation

John Collier

In these notes I want to address some issues concerning self-organisation that seem to me to apply generally from the micro-physical through the biological and social to the cosmological. That is, they are a part of the general theory of self-organisation. I prefer to distinguish the theory of self-organisation from the analysis of the concept of self-organisation (which Maturana claims is oxymoronic, since there is no self that organizes[1]). General usage gives us something to which the term ´self-organisation´ refers. We can set aside the question of whether or not selves can really do such a thing until we know what it is they are supposed to do.[2] This approach also allows the possibility that self-organisation does not pick out a single natural kind, but may refer to a range of things that are grouped together by a Wittgenstein style "family resemblance".

I will start with some ways in which self-organisation and related concepts are used in the current literature. Next, I will distinguish between two forms of self-organisation, neither of which is trivial, but the second of which is much richer than the first. Confusion of the two forms can lead to widely inaccurate claims. This is followed by a classification of different systems that have been discussed in the self-organisation literature according to whether they fit one or the other form of self-organisation, and whether or not they can be closed systems, or are essentially open. Next, I will list and describe the essential properties of the second, richer form of self-organisation, and set out some problems that need to be resolved if it is to be used systematically. Finally, I relate basic forms of self-organisation to a standard account of teleological properties that is used in biology.

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[1] In response to a direct question by Jeff Blumberg concerning Stuart Kauffman´s claim the idea of autopoiesis can be traced back at least to Kant. I quote from an email sent by Blumberg to Autopoiesis@Thinknet.Orange.ca.us: "Dr Maturana´s answer was basically that Kauffman should apply his theories in the correct domain and that he should stay out of area he knows nothing about. One thing that the good Dr did say I need clarity on. I quote Maturana: ´...I have said that the origin of living systems occurs as a case of spontaneous organisation...notice that I speak of spontaneous, and I do so because the selfness of a system arises with the system, so a SYSTEM CANNOT ORGANISE ITSELF...´" It is worth noting that Kauffman´s (1993) models are logical, unlike the more common dynamical models I will discuss, but although proving the equivalence of the approaches is too difficult to pursue here, the basics are in (Collier 1999a).

[2] See Collier (2004) for a direct response to Maturana.

Uses of self-organisation and related concepts

Self-organisation, as used in the literature, is a multiply ambiguous concept that covers a range of concepts and cases that often have less in common with each other than they have with other concepts. I will give some quick characterizations here of some central concepts and where they stand in relation to each other. Each of these concepts picks out systems that show changes in organisation such that the later states have an organisation that is more apparent than the organisation of earlier states, and the changes in organisation are not driven by external forces. I assume, though, that these two conditions give no more than a nominal definition of self -organisation, and that from a dynamical point of view these common elements are merely a family resemblance. It will turn out that the way that these two conditions are satisfied are quite different for different classes of systems, and some resemble non-self-organizing systems more than they do richer types of self-organizing systems.

Self-production is the process of regeneration of the (essential or the bulk of) conditions for ones own existence. An example is an organism. Other examples may be weather systems and globular clusters of stars. Self-reproduction is the special case in which a process regenerates the conditions for its own existence in stages in which each stage generates the required conditions for the existence of the next stage. Examples are lines of cellular reproduction and organismic reproduction.
Comment: self-production should not be confused with making oneself from scratch. It is a maintenance and, in the case of self-reproduction, propagation condition. Note that the self-production of a lineage of cells is a case of the self-reproduction of the individual cells. Self-production requires that the system actively maintain its existence conditions, rather than merely fitting into a minimal energy configuration. Weather systems and especially globular clusters, may not satisfy this requirement, and may be more like *self-assembling* systems.

Autopoiesis: This is a technical term that etymologically means the same as self-production, but which has a more restricted use. The restriction is to systems that are closed to information, so that external information is not used in self-production. They are said to be *operationally closed*.
http://www.cs.ucl.ac.uk/staff/t.quick/autopoiesis.html
Comment: self-producing systems need not be operationally closed, but may rely on predictable active organisation in their environment. Autopoietic systems are by definition operationally closed.

Self-assembly is a process by which more complicated forms occur without external guidance because of the properties of the parts. It may be either programmed or unprogrammed. An example of the former is proposed self-assembling nanotools, possibly also self-assembling molecular systems that used inherited information. An example of the latter is a set of lipids forming a membrane by orienting their hydrophilic ends outwards and hydrophobic ends inwards.
http://whatis.techtarget.com/definition/0,,sid9_gci516537,00.html
Comment: the end state of a self-assembling process is a minimal energy state. Self-assembly produces no new information, but the final state is in a sense programmed into the early states. If the "genetic program" idea of the genes were correct, then organisms would be self-assemblies from the genetic information and local matter and energy. Self-assembly is dissipative (otherwise a lower energy level would not be reached), but in no way creative. It works by eliminating unneeded information; it does not create information. Typically self-assembly is a passive process, but it need not be.

Self-maintenance is a process by which a system´s conditions of existence enhance its continued existence. Self-maintenant systems need not be self-producing. An example is a candle, another is the Bénard cell.
Comment: self-maintenance is dissipative, but it need not be active. It overlaps self-production, but in its simplest, non-active version it is the correlate of self assembly. This form of self-maintenance tracks minima in environmentally determined conditions, as in the Bénard cell. Homeostasis requires no more than this.

Autonomy is a property of self-productive systems in which the (central or bulk of) conditions for the existence of the system are definitive of the identity of the system. Such as system is essentially self-producing. Autopoiesis is a closed version of autonomy; other versions of autonomy make autonomous systems essentially open and interactive (e.g., Collier 2004 and references therein, also the use found in work by Hooker, Christensen, Bickhard and Moreno).

Organic: an organic system is one in which the organisation is integrated
Comment: etymologically, organic and organisation are linked, but the latter term has come to have weaker meanings. ´Organic´ is typically not used technically in the present sense.

Anticipatory system is one that can adjust its current state to modify its behaviour appropriately to deal with a future state of itself or its environment.

Comment: anticipatory systems range from externally programmed systems to autonomous systems that satisfy this criterion.

Synergistic systems are organized so that the organized system can do things that the components cannot do collectively but individually. The whole is greater than the sum of the parts.
Comment: the term originates from energy (from a word for work), with the connotation of working together. A synergetic system has no necessary connotation of being self-produced, but it may be. Self-organized systems must be synergetic.

Closure to efficient cause is a notion developed by Robert Rosen (1991) that is supposed to distinguish living systems. Efficient causation is the originating cause of a process. Closure to efficient causation implies that there is no external origination. (See autopoiesis.)
Comment: this appears to be a synonym for operational closure.

Complexity is an ambiguous term that is sometimes used (e.g., Rosen 1991) to refer to systems that cannot be modelled precisely in all respects.
Comment: In Rosen´s sense a complex system cannot be decomposed non-trivially into a set of part for which it is the logical sum. Rosen´s modelling relation requires this. Other notions of modelling would allow complete models of Rosen style complex systems, but the models would have to be what Rosen calls *analytic*, that is, they would have to be a logical product. Autonomous systems must be complex. Other types of systems may be complex, and some may go in and out of complex phases.

Self-regulation is the very weakest of teleological concepts, sometimes called *teleomatic* regulation, or cybernetic, also *homeostatic*. It uses feedback to keep its state within a range of values close to a set point. An example is an air-conditioning system with a thermostat. Another example is a missile that compares a representation of a target with its observations of a target in order to hit the target. A system with an internal governor.
Comment: anticipatory systems are self-regulating at the very least. In AI and robotics such systems are sometimes called autonomous, but this is a deviant usage (see Kant, *Critique of Judgement*, for early usage with regard to organisms and people).

Self-direction: a system is self-directed if it uses feedback to guide its activity (self-regulating), and also to alter its set points (second order cybernetic). Sometimes called *telonomic*.

Comment: self-direction may also refer to systems that have no specifically determined (localized and independent) set points, but this extension is potentially confusing, especially when the system is autonomous and sets its own rules. Set points should be distinguished from rules.

Self-organisation versus self-reorganisation

One of the most fundamental distinctions in processes that tend to promote organisation is between those where no new macroscopic constraints are formed and those where new macroscopic constraints emerge (Collier/Hooker 1999). The new constraints can be expressed either as structures or structured processes. The processes that produce no new constraints are essentially passive filtering, sorting and re-arranging processes, and we will call them *reorganisation* processes, in contrast to *self-organisation* processes, which do produce novel constraints. To facilitate comparison, consider an example of each. Coins are often sorted by being placed in a sorting box, above a series of graduated meshes ordered by mesh size (biggest size on top) and chosen so that each mesh size is intermediate between the corresponding coin sizes. The sorter is randomly jiggled horizontally and the coins are automatically sorted by size as each eventually falls to its appropriate mesh, the meshes acting as passive filters. The coins have acquired a small increase in organisation (von Foerster´s order-from-noise principle, with gravity the ordering principle) but the coin+sorter system has simply re-organized. On the other hand consider a collection of randomly positioned molecules at rest at equilibrium and then again subject to jiggling so that they acquire random increases in momentum; but this time suppose that they interact exothermically above some energy threshold, so that first one pair bonds as a result of a particular fluctuation, releasing energy, and in consequence an increasing cascade of bonds are formed, with the ultimate result that the collection condenses into a rigid, regular hexagonal crystalline object, releasing energy to form a surrounding radiation field. The molecules have acquired a small increase in organisation (through the ordering of bonding and radiative dissipation), this time through self-organisation.

First, consider what these cases share in common. Both systems have available an ordering principle and both are subject to uncontrolled perturbations which are required to initiate the organizing process, where ´uncontrolled´ means a variation not controlled by existing system constraints (i.e. by system structures and processes). These features are essential for either process – otherwise order would be created ex nihilo. Without an ordering principle there would be no coherent motion in either system, their elements would disperse at random like an uncontained gas. Without an input of perturbations, each internally (if idiosyncratically) ordered, there would be no external source of new order from which to generate the new system order and organisation.[3] For the same reason, in both cases these perturbations must be uncontrolled.[4] The point of their being random is only to ensure that sufficient possibilities are explored to make it probable that at least one them will contain order that can initiate system ordering in response. This requires, again in both cases, that the system dynamics (in particular the ordering principle) must be such that the order in sufficiently many inputs is effectively retained (not ´washed out´ by subsequent fluctuations) and perhaps even amplified. In the coin case gravity transforms the order in a horizontal fluctuation that brings a coin into an appropriate correlation with a mesh (namely, over a larger hole) into downward motion and these motions are retained and concatenated into sorter-scale order. In the crystal case bonding force transforms the order in motion correlation into retained bonding which concatenates into a crystal and also amplifies it radiatively to initiate other bondings, ultimately retaining it in the final radiation field. In both cases the systems pass through a symmetry-breaking transition which corresponds to the creation of order or physical information within them (Collier 1996). The coins begin randomly positioned, the correlation function among like coins identical in all directions, but end asymmetrically organized vertically; the molecules begin likewise but end hexagonally organized. In both cases the resulting system state changes some of its dynamical behaviour. The coins will now comprise a vertically organized sequence of masses, each of a distinctive size, density and total weight, where initially they comprised a single mass of yet different distinctive size, density and total weight, and these initial and final arrangements will each be characterised by a distinctive gravitational field, rotational inertia and so on, and hence interact distinctively with other objects. And similarly for the other case. Finally, in both cases the process is irreversible because of dissipation; the coins dissipate their falling kinetic energy as heat as they bounce to a halt on their mesh

[3] It is sometimes possible to provide sufficient ordered energy in the specification of initial conditions that the system will proceed with the organising process as a matter of moving toward equilibrium, e.g. by having the bodies in the latter case initially moving on collision courses at above-threshold energies, but this is just to replace one kind of ordered input by another.

[4] Symmetry-breaking through fixation of uncontrolled variations via internal system dynamics is *spontaneous* for the reason that, although the order implied by the symmetry-breaking arises immediately out of the system dynamics, it is not wholly controlled by the system dynamics, much as a person´s spontaneous outburst is not in itself deliberate, but nonetheless arises out of their underlying intentions and personality.

and the molecules dissipate their energy as release of radiation as they bond.[5] There are no reversible organizing processes proper since there is no increase in system order, hence there is no new organisation without dissipation. In the reversible case there may be shifts of order from one part of a system to another and these may mimic an organizing of one part, but such processes can only ever have a misleadingly derivative status with respect to organizing processes proper. All of these features are essential to all organizing processes - and thus none of them distinguishes between re- and self- organisation.

Consider then what distinguishes between the processes in the two cases. First, there is new cohesion formed in the crystal case but not in the coin case. The new constraints, respectively on the molecules in the crystal matrix and on the quanta in the radiation field, are each markedly different from those applying to the unbound molecules; the crystal molecules are now bound together cohesively into a rigid object while the radiation quanta can freely superpose, neither of which applies to the movement of the individual free molecules. By contrast there are no new cohesive constraints formed in the coin sorting case, both initially and finally they simply act under gravity. More generally, a self-organizing process is distinguished by the production of order at a higher constraint level (known as higher order redundancy in the communications theory literature) or the promotion of order from one constraint level to another. Second, and correlatively, neither the laws by which coins are governed nor those governing the sorter will have changed in the process, but in the other case the two emergent objects – crystal and radiation field

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[5] In the reorganizing cases the cost to system organisation through unavoidable dissipative losses in these processes are typically assumed sufficiently small and ignored because they do not disrupt the reorganizing process. They may occasion disruption elsewhere, when one part of a system is sacrificed to supply order to another, or they may be negligible or non-existent and the systems be quasi- or strictly conservative, as in reversible computations. A careful exposition would also distinguish systems whose organizing processes are equilibrium-forming, as in the crystal case, and those that occur in far-from-equilibrium dissipative systems, such as living systems. The perfect crystal is a very simple organisation, its structure does not allow new possibilities of self-interaction without breaking cohesion, so there is no order increase; both equilibrium and exothermic formation may be sufficient conditions for this organisational simplicity. Certainly, all living systems and complexly organized designed devices require endothermic formation, and the crystal quickly goes to an equilibrium state thus reducing intropy (negentropy, or available statistical order) almost immediately, suggesting that equilibrium, in contrast to far-from-equilibrium steady state, systems are degenerate.

– obey correspondingly different laws from those for free molecules. In the coin case the coin+sorter system uses its existing dynamical laws, in interaction with its environment, to reorganize itself without adding any new kinds of internal constraints and hence without changing its dynamical form. By contrast, during its organizing process the change in laws across the crystal-forming process is a change in dynamical form. Moreover, third, the change in form is quite specific: whereas in its initial state all the system components (the molecules) could in principle interact with one another so as to form correlated movements, typically time-varying, in the final state the movements of the molecules are invariantly, repetitively correlated and movements of individual molecules are not correlated or correlatable with the movements of quanta in the radiation field, even when the two interact. From a single interactive dynamics the dynamics has bifurcated into a fixed cohesive dynamics plus a collection of fluctuations uncorrelated with it. By contrast, there is no such bifurcation in the coin case. Thus, fourth, in the re-organisation case there is no phase transition and in the self-organisation case there is. Fifth, the result of the new cohesion formation is the construction of a new system level which filters out fluctuations on smaller scales. In the crystal case movement fluctuations in individual molecules resulting from interaction with field quanta are not preserved but dissipated as re-radiated heat from the crystal, the crystal literally averaging across such individual fluctuations because of its cohesion. There is no corresponding formation of relatively macro scale filtering in the coin case. [6]

Finally, sixth, it follows that in the case of self-organisation new kinds of possibilities will emerge because of the new cohesive level created. Thus the system will be characterised by increasing degrees of freedom in the relevant respects. These may be wholly new; the collection of separated molecules has no degrees of freedom as a rigid body (thus for rigid rotation, sliding, strain and stress – e.g. when supporting weights, and so on) or as an electromagnetic wave conductor (e.g. as a polariser) while the crystal does. In this case the new organisation enables new possibilities; that is, it makes possible possibilities that were not present in the system without the new organisation. Of course other

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[6] Note that there is no restriction on the size of the initiating fluctuations in relation to initial system scales, although fluctuations which are too small may be impotent and fluctuations which are too large may so disrupt the system that no ordered outcome eventuates. Typically, but not necessarily, the variation will be initially on some microscopic scale relative to system cohesion scale, which will explain why it is not controlled by the system. Water flowing over a stony river bed, for example, forms and re-forms standing waves as small flow fluctuations are amplified and fixed by the flow.

possibilities will also have been surrendered. The collection of molecules can disperse, stream and eddy, collect in odd shapes and so on. (Constraints are always both enabling and disabling – at the same time as they restrict possible forms of organisation by relaizing incompatible alternatives, they form the conditions required for mre complex constraints to form.) Thus there will be a sharp shift in degrees of freedom, a characteristic of phase transitions. In the reorganisation case there will be no such sharp shift since the dynamical form remains invariant, there can only be gradual quantitative alteration of existing degrees of freedom.[7]

These contrasts generalise to all cases. All the features of self-organisation are present, e.g., in the paradigm cases of Bénard cell formation, slime mould aggregation and others and are clearly absent from all the cases of re-arranging, sorting and filtering that leave the original elements and their interrelations unchanged. To sheet home this often mis-understood distinction, consider the following subtly different cases. First, a standard learning system, e.g. a neural net equipped with some error correction process, learns to discriminate environmental stimuli and provide a discriminated response. Second, consider the same example, but now with the net weights so arranged that if they fall in value below some threshold they pass irreversibly to zero, i.e. to effective disconnection.[8] In both cases the stimuli are uncontrolled perturbations for the net and environmental order in the stimuli is incorporated into system order and learning will correspond to increased system organisation. However, in the first case the laws by which the

[7] Self-organisation creates a cusp in the H_{MAX} (the maximal entropy of the system as all internal constraints not essential to the system are released) curve rather than the incremental increase of re-organisation. At the same time H_{ACT} (the actual entropy) will also increase, though more slowly, providing for an increase in order and organisation.

[8] This process is dissipative, though only described formally; in any physically realised version physical information must be lost to the system in the process. Similarly, any physically realised version of the first, standard net case would also be dissipative, although this is ignored in the standard description given. If the learning process is reversible in the first case the order can only be transferred from, not copied from, the environment. Technically, copying is not necessarily irreversible because of the logical possibility of reversible computation (Fredkin and Toffoli, 1982), but it requires the production of waste memory, required to be kept in reserve to perform the reversal. When the memory is erased, the reversal becomes impossible to perform. In real cases, there is no significant memory. On the other hand, the possibility of reversible copying and then memory erasure that eliminates the connections required to make the original order shows that order transfer is possible through irreversible change as well.

learning system works, e.g. neural net node and error correction rules, will not have altered and all net elements remain connected. The interactive system+environment super-system evolves from its initial condition under its unchanging dynamical laws and environmental information is simply transferred or copied into the system. In the second case, by contrast, the collapse of connections establishes new net-scale constraints which future fluctuations in net values cannot disturb, so that this new constraint formation acts as a macro level filter; the net changes its dynamical form and so passes through a phase transition. In short, in the first case we have learning through reorganisation and in the second case we have learning through self-organisation.[9]

In summary, in self-reorganisation the information in the final state is implicit in the initial state of the system, whereas in self-organisation proper new information appears. Both processes are spontaneous, but only in the case of self-organisation proper do we get the spontaneous appearance of information. Both processes are dissipative, but in reorganisation information is only lost in the dissipative process. There is a sense in which reorganisation is a mechanical working out of pre-established possibilities. Self-organisation, on the other hand, involves the manifestation of possibilities for new possibilities. In this sense, self-organisation, but not reorganisation, is strongly emergent, and entails genuine novelty. Self-reorganizing systems can be quite mechanical in their dynamics, and need not be

[9] Although the distinction between re- and self- organisation seems clear-cut, subtle issues arise in its application because of the internal complicatedness of living systems. Some of these have been initially explored in Collier (1986). Consider, e.g., a change which allows merely molecular DNA information to become genetic information by acquiring regulatory or expressive function (or, more variably, old genetic information to acquire new regulatory function), or which allows genes that are not phenotypically expressed for developmental reasons to become capable of phenotypic expression, thus being ´promoted´ from genetic information to phenotypic information. If these changes are analogous to the addition of new like molecules to the established crystal structure in the crystal-forming case they cannot be claimed to create a new cohesive level with new macro filtering, but if they are analogous to the addition of impurities whose consequence is to change the crystal structure radically enough (say, introduce new modular regional sub-structures) then they can claim to be self-organisation. How much genetic and phenotypic change is enough to make good a claim for self-organisation? Though we believe that principled answers are always available for such questions, answers which illuminate precisely where cohesion operates, how autonomy is organized, and so on, each case must be carefully analysed before a decision can be reached.

complex in Rosen´s sense, but self-organizing systems are necessarily complex in this sense. Of course both types of systems can be complex in the sense of being complicated. Whether or not the term ´self-organisation´ is used to cover self-reorganizing as well as self-organizing systems proper, the difference between the two is quite large. In both cases new organisation becomes manifest, and accessible, but only in the case of self-organisation proper do new constraints that are not fully explicit in the system appear. Since the notion of constraint directly implies information in the strictly syntactic sense, there is a sense in which self-organisation produces new information.

Scope of Self-organisation Concepts

Given that the distinction between self- and re-organisation is so fundamental, it is natural to divide systems into those that show the former, and those that show only the latter. This division is not quite fine enough, however, since self-organisation concepts also cover operationally closed systems. Operationally closed systems have stationary information, and are thus like reorganizing systems, but they are intrinsically complex, and must be produced, someplace in their past, by self-organizing processes. (This assumes, of course, that such complex systems really do exist. This is not to be taken for granted, since there are many scientists who hold that all organisms, for example, are formed through random variation and selection, which is a process of reorganisation – with its associated information loss.) For this reason, we need a tripartite distinction, which is really a family of gradations, running from the most mechanical reorganizing systems, through mechanically acting but complex self-producing but informationally closed systems, to the self-organizing systems proper, which are both energetically and informationally open.[10]

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[10] Cliff Hooker suggested to me that the topography of self-organizing systems is really three-dimensional, the axes being mechanical/non-mechanical, open/closed, and (informationally) stationary/non-stationary. I agree, but since only some of these permit systems that have been called self-organizing, and since some of the extremes are generally unpopulated, I use the simpler version here. The reorganisation cases in are on the stationary information plane, while the invariant cases are on the mechanical-stationary intersect (or close to it), whereas the self-organisation proper cases are on or near the non-mechanical, open, non-stationary extreme. We might imagine that reorganizing systems grade into invariant but complex systems as we allow them to be more open to energy and matter, but remain informationally closed. Then we open up the informational axis.

Given this set of distinctions, the self organisation concepts of the first section divide up roughly as follows:

Reorganisation (informationally invariant)
Self-assembly, Self-regulation, Self-direction (in its simplest form), Synergy (only in its simplest form), Self-maintenance (in the simplest form).

Invariant but complex
Self-producing, autopoietic, closed to efficient cause, organic (?), dissipative structures

Self-organizing proper (informationally open)
autonomous systems, turbulent systems

The notions of synergy and organicity can apply to all of these categories, and are not sufficiently fine grained to be useful in themselves. The latter two categories contain only intrinsically complex systems, but the first category also contains some complex systems. May of the notions in the first category also apply to systems in the second two, but not vice versa. Likewise, many of the notions in the second category apply to systems in the third, but not vice versa. Autonomous systems are anticipatory, but turbulent systems typically are not. The latter lack invariance, some degree of which is required for anticipation. Autonomous systems, as well as the systems of the second category, must be anticipatory, since the active maintenance of the invariance that constitutes their viability is essential to their existence. Systems in the first category may be anticipatory, as may some entirely externally designed systems that are in no way self-organized.

Form this classification it is perhaps evident why self-organisation is a family of concepts rather than a single essence. Autonomous systems have some affinity with turbulent systems, but also with the second category. The second category, on the other hand, contains essentially complex systems like the third category, but the requirement of informational or operational closure gives it an affinity with the more mechanical members of the first category. The closure to information restricts members of the second category to reorganisation alone.

Conditions required for self-organisation

The necessary conditions for the possibility of self-organisation proper are 1) an applied force, 2) internal cohesion, and 3) an internal entropy gradient. The system will, of course, also have various transport coefficients (like thermal conductivity) resulting from interactions among its parts necessitated by internal cohesion. It will also have a physical size and shape, and will be physically confined.

For our purposes, the important characteristics of dissipative systems are as follows:
1. Phase separation
2. Free energy (exergy) source
3. Exportation of entropy from system (energy degradation)
4. Promotion of microscopic fluctuations to macroscopic order
5. System organizes itself so as to minimize local entropy production in the generalized direction of the applied force (Prigogine 1961).
6. The efficiency of energy throughput under force is maximized.

Note that condition 3 implies 2, condition 4 implies 1, and condition 5 implies 6. Condition 6 is somewhat controversial, mostly because it is easy to misinterpret. Efficiency of energy throughput means that friction is minimized, and work potential is maximized. We all know that neither of these conditions is true globally within any complex system. In particular, all other things being equal (they seldom are, due to effects of tuning and other harmonies), increasing work output increases friction even faster. The explanation for this is that the efficiency of energy throughput in the generalized directions not under force can very well drop. Under turbulent conditions in which the directions of energy flow are unrestricted, this effect can lead to a maximization of global entropy production, as has been postulated for the atmosphere. If some informational (actually organisational) invariance is required or formed in the process of self-organisation, as happens in autonomous systems, then the very processes that produce this invariance also restrict the ways in which energy can be dissipated, and global entropy production cannot be maximized. At least some energy is passed through efficiently. This constrains any tendency toward chaos, and has a pacifying effect on the overall system (in contrast to highly turbulent systems). Once this tendency is manifest, it can cascade in a self-reinforcing way to produce highly efficient organized systems, though this result is by no means necessary, and requires favourable conditions, neither too energetic, nor too calm; neither too diverse, nor too uniform. This makes it very difficult to make universal generalizations about the dynamics of complex self-organized systems. We can say, though, that the spontaneous nature of self-organisation proper makes it impossible to fully control. The best we can do is to provide the conditions that facilitate the sort of self-organisation that we want to see. This applies whether we are dealing with external physical systems, our own bodies, social systems, or our own psychology.

Conditions 1-6 follow immediately from the circumstances of the Bénard case, one of the simplest and best studied of dissipative structures formed through self-organisation. Phase separation is just the distinction between cells. A high temperature heat source is required, and heat must be transferred to a lower temperature reservoir. Maximization of energy throughput is a consequence of local minimization of entropy production. This result can be the most difficult to understand intuitively. Schneider and Kay (1994) also propose that the reorganisation of the system minimizes the deviation from equilibrium. This is consistent with minimization of local entropy production (Prigogine, 1961). The system takes the path of least resistance. Instead of "wasting energy" on large scale random fluctuations, it convects in an orderly manner. The reason the fluid does not convect below the critical Rayleigh number is that the viscous dissipation is too high: the buoyancy of the fluctuations is insufficient to overcome the viscosity.

Glansdorff and Prigogine pointed out that local entropy production is stationary in a system in a steady state, and can otherwise only decrease. The transition between conduction and convection, then, can be understood as a minimization of local entropy production. The gist of this is that the system organizes itself so as to minimize its entropy gradient. Convection allows macroscopic order to reduce local entropy production when local fluctuations are too large to disperse locally. The fluctuations are dispersed by moving them to where they can be dispersed more quickly. This permits energy to move more efficiently through the system, in effect reducing friction.

Although there is much more to be understood, in the Bénard case it is relatively easy to see how properties 1-6 follow from the necessary conditions. In most other cases, however, it requires considerable ingenuity. The additional complexity arises from greater structure in the components of the system and the ways they can interact. First, there is the possibility of differentiated components that respond to applied forces differently. Given such differentiation, the components can interact with each other differentially. Typically, this additional complexity allows more diverse possibilities for self-organisation, which in turn leads to diverse structures, which generate new possibilities for being affected by forces, and for interaction, and the potential cascade of organized complexity has no clear upper bound, as long as the system remains in gradients of energy and information quality, some of them having been generated within the system. This complexity and differentiation permits increasingly fine responses to environmental influences, lending the possibility of adaptive behaviour. It also allows the possibility of hierarchical organisation with relative independence between levels, and the emergence of new forms of system with, so to speak, a life of their own.

End directedness

Basic dissipative systems have an end, which is to say that they are temporally asymmetrical, but they do not construct their own means to their end. Such systems are called *teleomatic* in the biological literature on function. This evokes the somewhat mechanical and blind nature of their finality. In fact, they respond only to local conditions, and their final causation is not internally distinct from their efficient causation. This is also true of the other most basic members of the reorganizing class, including self regulating and self assembling systems. The machine like nature of such systems is usually readily apparent. Self-maintaining systems and self-directing systems may share this mechanical character, but they do have an implicit representation of their end, either as a condition that regulates their direction and speed or else though their selection of set points, whether this has arisen through accident or design. Still, such systems are essentially teleomatic, since their finality is not an essential part of their nature, and arguably nothing is lost in ignoring any teleological considerations in explaining how they work.

The next level of end-directed concepts is teleonomy, which is manifested when there is an end, and the thing pursuing the end depends on this end for its very existence. Organisms show teleonomy because their end is first of all their own viability. In this case their very form or organisation is such that it is directed toward this end. It is reasonable, then, to think of organisms in terms of formal causes, and not just efficient causation. Their end is not explicitly represented, but it is present in the system in a way that it is not in teleomatic systems, that is, in the system organisation itself. For this reason it is useful to characterize the organisation in terms of functionality. However, this functionality is not intentional, since there is no explicit representation within the system. Teleonomy can be more articulate than mere survival, if the maintenance of relatively modular subsystems permits subgoals and dependent ends. This allows for a more articulate functionality, which in the extreme permits specific functions for specific modules, similar to what we see in engineering designs. It should be stressed, though, that the individuation of functions in this way is by no means necessary, and it may not even be optimal in terms of overall functionality. Thus the existence of teleonomy does not in general support the assignment of functions rather than functionality, but in some cases the assignment of functions may be possible. Each case, though, requires a specific argument.

Beyond teleonomy is full fledged teleology, in which there is an explicit representation of goals in a system accessible form. This permits the direct manipulation and selection of ends, and is the basis for intentionality. In this case, explanation that avoided final causes would be remiss.

Each of these levels of end directedness can coexist with the others. It is quite possible that a given activity may exhibit all these forms of teleological properties. For example, society´s heavy use of resources is the result of explicit decisions by specific people and groups of people for clearly represented and openly discussed goals, often serving ends like survival, comfort and the continuation of ones biological or social lineage. These explicit goals, however, can also serve less explicitly but still socially and individually embedded goals like survival of our economic system and our culture, even though these might not be fully represented, or even represented at all except tacitly in our social structure. Despite this, the end of our consumer society might be ecological catastrophe. This end is at best poorly represented, and need not be represented at all for it to be the most definite and inevitable of teleomatic ends. The suitable form of analysis and explanation in each case would be quite different, with final causes appropriate for the represented ends, formal causes for the teleonomic ends, and efficient causes for the teleomatic ends. It would be explanatorily dubious, for example, to explain the hypothetical teleomatic end of ecological catastrophe in terms of a societal death wish, explicit or buried in the collective unconscious, no matter how much it might seem that way from a design stance.

References:

Collier, John (1986) *Entropy in Evolution*. In: Biology and Philosophy 1: 5-24.

Collier, John (1996) *Information originates in symmetry breaking*. In: Symmetry: Culture & Science 7: 247-256.

Collier, John (1999a) *Causation is the Transfer of Information*. In: Howard Sankey (ed) Causation, Natural Laws and Explanation. Dordrecht. Kluwer.

Collier, John (2004) *Self-organisation, Individuation and Identity*. In: Revue Internationale de Philosophie.

Collier, John and C.A. Hooker (1999) *Complexly Organised Dynamical Systems*. In: Open Systems and Information Dynamics, 6: 241-302.

Fredkin, E./Toffoli, T. (1982) *International Journal of Theoretical Physics* 21: 219.

Kauffman, Stuart F. (1993) *The Origins of Order: Self-Organisation and Selection in Evolution.* New York. Oxford University Press.

Prigogine, Ilya (1961= *Introduction to Thermodynamics of Irreversible Processes, 2nd Edition*. New York. John Wiley and Sons.

Prigogine, Ilya (1980) *From Being to Becoming*. San Francisco. Freeman.

Rosen Robert (1991) *Life Itself: A Comprehensive Inquiry into the Nature, Origin and Fabrication of Life.* New York. Columbia University Press.

Schneider, Eric/Kay, J. J. (1994) *Life as a Manifestation of the Second Law of Thermodynamics*. In: Mathematical and Computer Modeling. 19, No. 6-8: 25-48.

Principles of Synergetics

Vladimir Budanov and Natalya Savicheva

Mankind is undergoing a global civilization crisis, which can be compared only to the late Stone Age crisis, when the large extermination of animals made people turn from hunting to agriculture. And now again humans have reached the borderlines of the biosphere and suffer recurrent blows – these are non-linear reactions to its expansion. This is a typical process of eco-niche in filling.

We have entered, as E. Lazlo said, "the bifurcation epoch". It has emerged from an interference of many cyclical socio-cultural processes at an unsteady self-destructing border, the border of the technogenic civilization´s extensive development. And along with it, self-organisation processes of a new informational society are developing. Noosphere mechanisms of this society seem to promise a mild scenario for resolving the planetary crisis.

To prevent chaos and develop a strategy of behavior within it, a new transdisciplinary language of horizontal connections is needed. The meta-language should be similar to a symbolic language of a pre-scientific knowledge (philosophical and traditional) but it should take into account new ratios. The integrity of knowledge as a new fundamental dominating paradigm of Becoming should solve the problem of two cultures, overcome the subject-object dichotomy of our mentality and restore a harmonic relationship between man and nature.

This holistic archetype has been formed at the end of the 20th century. In modern science it is represented by synergetics – an interdisciplinary approach that investigates mechanisms of evolution, the Becoming of reality, and self-organisation. It is aimed at the strategic task of "managing" chaos (Haken 1980).

Synergetic principles apply to both the humanities and natural sciences, especially to the life sciences. This synthesis started spontaneously due to the logical development of science itself, the integration of its disciplines, the consideration of more and more complicated systems in physics, chemistry, and biology, including the modeling of social and psychological phenomena. Due to the complexity of their behavior, these systems begin resembling living organisms or their communities. Besides, the principal unremovability of the role of the human being role as an observer and an experiment interpreter has been realized. That means that only a holistic approach that tries to unite nature and man is topical (nature + man). Synergetics is guided by modern mathematical methods; it can also be considered a far-reaching development of Darwinism. Actually it may be called "evolutionary natural science" in a wide sense. (Stepin 1992, Kurdyumov/

Knyazeva 1981, Arshinov/Budanov 1994). Following Ilya Prigogine, from Being to Becoming is a new scientific paradigm orientation, in the context of which the focus is being moved from investigation of systemic invariants and equilibrium states to the investigation of non-stability states, mechanisms of emergence and system restructuring (Progogine 1984). For example, there now appears an opportunity to describe self-organisation phenomena in a universal way. The meaning of a system´s openness, the constructive role of chance and chaos, the nature of catastrophic revolutionary changes in the system, its alternative historical development mechanisms, and many other phenomena are becoming clear.

It is interesting that all these conceptions are gaining a deeper meaning now. The development of a new language has become possible, which is more than a metaphoric one. In fact, it is the common meta-language of natural sciences and humanities. It is quite reasonable though one of the cultures represents mainly a rational way of perceiving the world and the other an additional, intuitive, associative-imaginative one. The essence of their dialectical unity is that none of them is self-sufficient. According to Kurt Gödel´s famous theorem on incompleteness, none of the cultures can keep developing without the methods of the other´s. Otherwise it will become a frozen doctrine or an absurd chaos.

Let us examine the concept of synergetical principles in the way one of the authors has laid out in his course “Modern Natural Science Concept” in Moscow State University (Budanov/Melekhova/Sukhanov: 1995). This concept is based on the development of synergetical principles, presented in Arshinov/Budanov/Voitsek-hovich (1995). Mathematical, logical and philosophical principles are discussed in detail in Arshinov/Voitsekhovich (1999)

Any evolutionary process is expressed in a chain of oppositional quality changes – conditional states of order and chaos in the system, which are connected by transfer phases leading to chaos (structure´s collapse) and out of chaos (self-organisation). We only refer to one of these four stages – the stable one – as Being or homeostasis of the system. Very often this stage is the longest one. The other three are in this or that way connected with chaos and referred to as becoming or crisis. The conventionality of this division depends on the fact that in any order one can find elements of chaos, and vice versa, in chaos one can find elements of order. The problem is in the level of their presence in each other. The relatively short duration of deep crises can be explained by the *evolutionary safety* of nature. A prolonged crisis rapidly decreases the system´s ability for adaptation and the system goes down, its integrity vanishes. That is why nature “prefers” to evolve in small steps instead of creating a man of clay at once.

Universal methods and the language describing these stages are well developed in synergetics. But beforehand, we are going to mark the main approaches. In the simplest variant it is possible to offer 7 general synergetical principles: two principles of Being and five principles of Becoming.

The Two Principles of Being: Homeostasis and Hierarchy

These principles characterize the phase of "order", the system´s stable functioning, its rigid ontology, transparency and simplicity of description, Haken´s hierarchical slaving principle, the presence of steady dissipative structures´ attractors which influence the system functions.

Homeostasis

Homeostasis means keeping up the system´s program of functioning and its internal characteristics to the extent that helps the system to approach its goal. According to Norbert Wiener, and following Aristotle, any system has teleological nature, that is it has a goal of being. And it receives corrective signals from its goal-standard-ideal (real or imaginative), which helps in not to loosing the way. The correction is accomplished by means of negative feedback (a part of the output signals are delivered as new input signals with reverse values), which suppresses any deviation in the system´s behavior program occurring under the influence of the environment. Precisely in this way all the living systems behave most of the time. For instance, warm-blood animals keep their body temperature constant under influence of the whole wide range of outer temperatures. An autopilot on the plane keeps the course and the height of the system in accordance with a gyrocompass in spite of air pockets and gusts. The aim-program of the system behavior at a homeostatic state is called *attractor* (puller).

We can find the simplest attractors in mechanics: a waving pendulum gradually goes out in the lowest point, and the ball stays on the bottom of a hole – these are the attractors of equilibrium. But there can be also more interesting attractors: the eagle glides in the up-going air current, the ping-pong ball hangs in the vertical stream of air produced by a vacuum cleaner, etc. But when the wind comes down and the vacuum cleaner is turned of, the eagle flies away and the ball falls down. These structures can exist only as long as the matter or energy flows exist. These are dissipative (diffusing energy) systems far from equilibrium. All living systems are dissipative structures, they collapse without a constant exchange of matter and energy, without homeostasis.

The principle of homeostasis can be found in many cybernetic ideas, systemic analyses and synergetics.

Hierarchy

Our world is subordinate to hierarchy in different aspects. For instance, in scales of length, time, or energy. It means, for example, that the universe´s basic structures don´t accept all possible energy meanings, but only with a relative step of approximately 100 times, beginning with quarks and finishing with living organisms (Weiskopf´s stairs). The number of levels itself is immensely large, and every basic structure contains a lot of sublevels.

The main meaning of structural hierarchy is the composite nature of upper levels in respect to lower ones. Something that for the lower level is a structure-cosmos, is for the upper one a unstructured element of chaos, a building material. This means that the cosmos of the previous structure is chaos for the next one. And we say: nucleons are formed by quarks, nucleuses by nucleons, atoms by nucleuses and electrons, molecules by atoms, … , society by people, and so on. A non-material hierarchy is also possible, for instance, in language (words, phrases, texts) and in the world of ideas (opinions, views, paradigms, ideology), in managing levels of society´s structure, etc..

Every time when *elements get connected to the structure, they deliver the system a part of their functions, degrees of freedom*, which are then expressed on behalf of the whole system. There is a possibility that new system qualities have never been characteristics of elements before their synthesis. For example, the average statistical subject "expresses" public opinion, but it can turn out that no individual exactly thinks this way. These collective variables "live" at the higher hierarchical level in comparison to elements of the system. In synergetics, following Haken, they are usually called *order parameters* – they describe the meaning of behavior and the system´s aims-attractors in a succinct format. The described nature of order parameters is called *slaving principle*. This principle means that the change of an order parameter launches simultaneous behavior of many elements belonging to the lower level of the system. Slaving can be found e.g. in the role of legislation in society, when citizens delegate to it a part of their rights; or in a whirlpool where there is a turbulent stream of water involving self-organizing particles.

The impossibility of complete reduction, turning structure´s qualities of more complicated hierarchical levels to the language of simpler system levels, is an important quality of hierarchical systems. Each level has an internal complexity limit of description, which can´t be exceeded in the language of this very level.

There are zones of language opacity – semantic chaos. This is another reason why language hierarchy corresponds to levels hierarchy. That is why the attempt of vulgar reductionism, explaining all life and psychic phenomena with the laws of elementary particle physics and assuming that everything consists of a static substance of particles, is absurd. Arguing in such a view is like the joy of a kid who has broken an expensive Pentium – looking through the chips-centipedes he proudly says that he understands at last how his dad´s computer is built. By the way, this is a necessary stage of a deeper level of knowledge of matter. Physics of the latest century has regularly opened ´matreshkas´ (broken pentiums), they have hit them more and more energetically warming the matter or speeding it up by accelerators.

Time plays the main role in a systemic hierarchy. *Haken´s synergetical slaving principle is formulated especially for time hierarchy.* Let´s imagine our reality to be an endless chain of structural time level-scales, beginning with today´s fastest processes in micro-world and finishing with time-scales of universe life. But actually it can be the world of non-physical phenomena.

Let´s now examine three arbitrary nearest successive time levels. Let´s name them micro-, meso-(or macro-) and mega-levels. *Order parameters* are considered to be long-living collective variables which set the language of the middle meso-level. They themselves are formed and governed by quick short-living variables, which set the language of the lower micro-level. The latter are associated at the meso-(macro-) level with an unstructured "heat" chaotic motion, which cannot be described in the language of its level in detail. The next level, above the macro-level, is the mega-level that is formed by super-slow "eternal" variables. These "eternal variables" play the role of order parameters for the macro-level, they are called *control parameters* (governing parameters).

So, each system level has concepts, ideals, "chaos" and "eternity" categories which serve as attributes of presence of the neighboring micro- and mega-levels and as the principle of system openness. It belongs to the hierarchical chain of the universe. These categories are ancient archetypes that have always existed in human culture. The variables of the macro-level – order parameters, which have emerged from chaos – set the ontology, the laws of Being and the order of Being of the level.

At a bifurcation point (*) the macro-level disappears and in a direct contact the micro- and mega-levels create a macro-level with other qualities. A bifurcation point is an instant for the macro- and the mega-level, and it is a crisis prolonged in time for the micro-level.

Observing the two neighboring levels of being we take into consideration *the slaving principle: long-living variables govern short-living ones*, an upper level controls a lower one. Microscopic motions of chaotically moving molecules can be organized into a tangible wind gust, which takes them away on a tremendous distance, in comparison with that of micro motions. Migration streams of population determine the distribution of individuals; and cultural tradition is reproduced in many families during the course of the generations´ being.

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t```` ...................................|.......................................
t``` ----------------------------|---------------------- mega-
t`` ----------------------------*---------------------- meso- (macro-)
                                 / \
t` ----------------------------/~~\-------------------- micro-
t ................................/.......\..................................
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Fig. 1. Time hierarchy of scales (dt) of co-evolving levels ...>>dt```>>dt``>>dt`>>...

It is important to mention that *the slaving principle is not always appropriate.* It should not be considered as something absolute. It is not always possible to point out the way an order parameter or a control parameter emerges from the lower level variables. This formation frequently took place long ago and not these variables took part in it. We can just observe an inherited hierarchy or a seeming one. For instance, the majority of processes on the Earth are this or that way connected with daily, yearly or lunar cycles. This means that these periods are control parameters for the planet, its biosphere, though earthly events themselves do not influence them at all. Here it is necessary to return to the roots of the emergence of the solar system from a gas-dust cloud, when the substance of the future stars and planets was whirling in a single round dance, dissipating energy in collisions and shrinking towards the rotation axis and close to resonance orbits. It was the very process of the emergence of order parameters. This way heavenly bodies were formed, matter concentrated in planets, and then the active dissipation-evolution was going on namely on them and on the sun. Cosmic rhythms became a conservative memorial of the early creation epoch, evolutionary codes of our star. In this respect not every slow parameter will be "more important" than any quick one. We have a co-evolution of quasi-independent hierarchical systems: our pulse and breathing hardly depend on a year season. Children become grown-ups and start living by themselves, create their families, and clannish ties become loose with the growth of the number of generations. Once united and dense, the universe becomes represented by separate islands of star substance. The first parent languages are lost in the motley variety of different races´ dialects. Extinct archaic organisms produced a fantastic variety of living species. All these are evidences of the fact that hierarchy cannot be set once and forever. It cannot be explained merely by the principle of Being, the principle of order. Principles of Becoming and evolution are needed in order to explain the world.

Five Principles of Becoming: Non-linearity, Non-stability, Non-closeness, Dynamic Hierarchy, Observability

These principles characterize the phase of transformation, a system´s renewing, its successive development from the vanishing of an old order, through chaos, testing of alternatives and at last the emergence of a new order.

We begin with the first three principles, "three nons", which have been avoided by the classical methodology. In fact, they let the system enter a chaotic creative phase. Usually it takes place due to positive feedbacks increasing incoming disturbances in the system.

Non-linearity

Linearity is one of the ideals of simplicity, many generations of mathematicians and physicists have tried to reduce real tasks to linear behavior. It is wonderful that it can be always done near the state of equilibrium of the system. Images of this behavior are well known: little (harmonic) vibrations of a pendulum or that of a cargo on a spring, equal or uniformly accelerated motion of bodies that we know from school. It turns out that in undergraduate school pupils are taught to solve mainly linear tasks (linear differential equations) developing a linear intuition in people, creating the illusion of the world´s simplicity. A system´s homeostasis often takes place exactly on the level of linear vibrations close to optimal parameters. That is why a simple linear case is so important. It saves intellectual efforts. The determining quality of linear systems is the superposition principle: a sum of solutions is a solution. In other words, the result of summarizing the influences on the system is a sum of results, a so-called linear system response, directly proportional to the influence.

Let´s imagine that the whole world consists of linear systems. It would be just boring: atoms wouldn´t be able to loose a single electron, this means that there wouldn´t be any chemical reactions; people wouldn´t have unexpected emotions and wouldn´t fall in love; it would be impossible to create anything new, to synthesize or to divide anything. There would be nothing to do in this world.

So, *non-linearity is the violation of the superposition principle in a phenomenon: the result of the sum of influences is not equal to the sum of their results*. The results of acting stimuli cannot be summed up. In a more qualitative sense: the result is disproportionate to the efforts, inadequate to the efforts; the whole is not the sum of its parts; the quality of the sum is not identical to the quality of the components, and so on. The latter, in particular, results from the fact that the number of ties between a system´s elements increases faster than the number of elements themselves.

People make forecasts, knowingly or unknowingly extrapolating (continuing) linearly the present or the near past into the future. Often expectations do not come true. Hence the proverb: "History teaches us that it does not teach us anything". History is by all means a non-linear process, and its lessons are not supposed to develop a conditioned reflex to current events. But this does not mean that we should reject a fast linear prognostication, which is the main standard of our thinking. But it is necessary to know the limits of such applications.

Any border of object integrity, destruction, separation, absorption supposes the presence of non-linear effects. It is possible to say that non-linearity "lives" and vividly becomes apparent near borders of a system´s existence. Non-linearity is intuition of a border. An elastic body for instance looses elasticity before breaching, in fact it becomes plastic. While swinging gradually a stuck automobile, little linear vibrations take place for some time (a wheel returns to the bottom of a pit), but at a sufficient span (rolling up to a mound) vibrations become non-linear, back-moving power begins to decrease and the wheel goes out of the pit, the system overcomes the border of attraction domain, homeostasis, and motion receives a degree of freedom. In a general case, in order to change from one homeostasis state to another we need to get into the sphere of their common border, the sphere of strong non-linearity.

The stronger attraction domain and the larger homeostasis sphere the higher the barrier. That is why it is better to learn swimming correctly from the beginning than to get re-training afterwards. Radical perestroika (re-building) of a system that is close to a deep homeostasis needs greater efforts.

Sense organs also have non-linear characteristics of sensitiveness, borders of perception. Otherwise, we would be all-seeing and all-hearing fairy-tale creatures (having all frequencies and intensity of vibrations and radiation at our disposal). Our brain would not be able to cope with the excess of information volume. Besides, the sensitivity scale is not a linear function but logarithmic. That is why when sound intensity increases 100 times, it still seems to us that it is only two times louder. This allows us to hear the rustle of a fallen leaf as well as a thunderclap though their intensities differ millions of times.

Human relations themselves have an extreme non-linear character because there is not any border of senses, emotions, or passions. Human behavior becomes "inadequate" when close to the borders. Also, collective actions cannot be brought to a simple sum of independent individual actions. For instance, a young lady, having invited her admirers to her birthday party, dares to get into a quarrel instead of holiday and looses many of them. Non-linearity makes it a challenge to hire effective personnel for a company or a project, or to choose business partners out of many professionals who in fact apriory seem to formally guarantee success. Non-linearity is also the task of making decisions or choices.

Non-closeness (Openness)

The quality of non-closeness has been frightening researchers, blurring the meaning of systems, promising uncontrolled problems. In spite of the fact that all natural systems are open to this or that extent, historically the first classical idealization was a definition, a model of a closed isolated system that did not interact with other bodies. It was an image of a little universe that can be placed on a palm, transparent and subordinate to our mind. We extracted it, separated it from the complicated world and started watching it.

It is important to understand that any system can be considered closed for a limited period of time. The larger an open system the shorter is the period it can be considered a closed one. And if this period is sufficiently larger than that of describing-observing the system, then such a model is justified. For instance, the Earth is an isolated free hyroscope rotating around the sun. But the interaction with the moon, unaccounted by us, leads to a slight slowing of the hyroscope rotating speed. Interaction with the sun leads to a slow turning of the hyroscope axis (precession) with the period of 26 thousand years (the so called Plato´s year). In the course of a human generation these effects are completely unnoticeable. While culture knows only the second phenomenon, and it is due to astrology through so called Zodiac constellation epochs (one twelfth part of Plato´s year: the Fishes, the Aquarius,…).

Fundamental laws of conservation can be applied to closed systems (energy, impulse, impulse moment). These laws make the description of a simple system much easier. But the most important fact is that the second law of thermodynamics (the second basis) applies for closed systems with a large number of particles. The essence of the law: entropy S (the measure of disorder) increases in the course of time, or remains constant, S ≥ 0. That means that chaos in a closed system does not decrease, but can only increase, and the order is doomed to disappear. So, a closed system cannot increase its order. A closed universe leads to chaos – thermal death. The scientific community of the 19^{th} century was shocked by this fact, but then it got accustomed to it, perhaps because it was assumed that it would take a long time until this would happen.

The very existence of life as well as of a highly organized mind seeming to regulate the world, contradict this perspective. But law is law, and living organisms and human civilization create order in and around themselves by means of common order decrease, planetary entropy. Living systems themselves and society are open systems, consuming substance and energy. The second law of thermodynamics is not applicable to them and entropy can decrease.

Namely the openness allows such systems to evolve from simple to complex forms, to develop the program of the organism´s growth from a cell-germ. This means that the hierarchical level can develop and become more complicated only while exchanging substance, energy, or information with other levels.

Dissipation in inorganic nature (transformation of incoming energy into thermal one by means of the system) can lead to ordered structures. For instance, the evolution of the solar system or a road of eddies following an oar in fast-running water behave themselves this way. Synergetics took its beginning in chemistry and laser theory exactly with the description of such systems.

It turned out that while coming from one homeostasis state to another the system in the sphere of strong non-linearity becomes obligatorily open in instability points. Even if you use an initially closed model, in these points it is necessary to widen it until it´s open. For this purpose it is necessary to examine the next principle.

Non-stability

The last one of the three “nons” (non-linearity, non-closeness, non-stability) contains the two previous ones, and it has actually been considered as drawback for a long time. Who will start constructing an unsteady bicycle or a plane? These “dead” points in mechanisms and engines, which should be slipped by inertia, are a special engineering task. It has been considered this way until now. But a new generation of robots able to be rebuilt from one homeostasis program to another was needed, as well as teaching systems ready to accept different behavior models.

The non-stability archetype can visualized e.g. by an upturned pendulum that is ready to fall to the right or left according to the smallest influences from outside or occasional thermal changes of pendulum substance, This was considered as absolutely inessential in former times. Thus, at the non-stability point the system (even closed) is really open and appears to be a sensitive receiver of other existing level´s influences. The system can receive information that had been inaccessible earlier.

It is now accepted to term these non-stability states, the states of choice, *points of bifurcation* (literally: a bicuspid fork, though the number of its alternatives can be more than two). These bifurcation points are present in any situation where a new quality emerges, and characterize the boundary between the new and the old. For instance, the climax of a pass separates a valley from another, it is an unsteady state of a ball on a knob.

The significance of bifurcation points is that only in these points it is possible to influence the choice of a system behavior by means of any weak impacts in a non-forced informational way.

There are systems where unstable points appear almost everywhere, for example – developed turbulence and chaos, a seething stream comes which leads the system to uncertainty. Synergetics provides means to describe such systems.

Dynamic Hierarchy (Emergence)

This is the basic principle of a system that runs through bifurcation points, it describes the forming of a system, the collapse and emergence of hierarchical levels. This principle describes the emergence of a new systemic quality on a horizontal level, when slow changes of the control parameters of the mega-level result in bifurcation, the non-stability of the system at the macro-level and its structural rebuilding. Everyone knows the metamorphosis of water (steam-liquid-ice). It takes place at a sharply determined temperature phase transitions, bifurcation temperatures – critical values of control parameters. At the level of a qualitative description the interaction of mega- and macro-levels is habitual but not explicable. A description of the third, the micro-level, is necessary. It has become possible in the second part of the 20^{th} century to describe the process of the disappearance and emergence of a macro-level at the bifurcation point in the language of the three mega-, macro- and micro-levels. At the bifurcation point collective variables, macro-level order parameters, return their degrees of freedom to the chaos of the micro-level, dissolving into it. Then in a direct interaction process of the mega- and micro- level new order parameters of a renewed macro-level appear.

An adequate constructive point of view on becoming has always been present in culture. In modern systemic language it has been represented by a triad: means of action + object of action = result of action.

In synergetics, the creative triad is represented as a process of the emergence of order parameters, structures are formed out of chaos at the micro-level:

“super-slow control parameters of the upper mega-level” + “short-living variables of the micro-level” = “order parameters, structure-forming long-living variables of a meso(macro)-level”.

Hence, there is a at a first sight paradoxical result (according to the Russian physicist Y. Klimontovich): The emergence of turbulence, e.g. the whirlwind of running liquids, is not an increase of disorder, but the emergence of collective macro-motions, macro-degrees of freedom and order parameters out of chaotic Brownian motions of a liquid at the micro-level – the emergence of order. We still can see it as disorder from a macro-level position, with the increase of macro-level complexity and unpredictability.

A moment between the past and the future – a bifurcation point – appears to be an epoch of changes and transformations at the micro-level. Exactly here a choice or rather an evolutionary selection of alternatives for the development of the macro-level take place. The theory of dynamic chaos gives attention to these issues.

For example, a public transportation strike returns us to the joy of freedom of independent movement for some time; anarchy and vague periods of social development return people to a freedom to choose ways of life and defending their property all by themselves. These burdening degrees of freedom make us overcome chaos, crisis, public bifurcation.

Observability

The principle of observability stresses the limitations and relativity of our ideas about the system in the ultimate experiment. In particular, it corresponds to the principle of relativity towards the means of observation, which was established by the theory of relativity and quantum mechanics. In the theory of relativity meters and seconds are different for each moving observer, and what happens simultaneously for a person is not simultaneous for another. In quantum mechanics, when measuring precisely one value we are doomed to be unaware of many others (Bohr´s complementarity principle). *In synergetics, we have a relativity of interpretations of the scale of observations and of an initially expected result.*

On the one hand, what is chaos from a macro-level position becomes a structure on the micro-level. I.e. *the definitions of order and chaos, Being and Becoming are relative to the scale – there is a window of observations.* The holistic description of a hierarchical system is formed by communications between observers of different levels, similar to the way observers of different inertial reference frames in the theory of relativity communicate with each other, or the general scientific picture of the world is formed from a patchwork of disciplinary pictures.

On the other hand, the interpretation problem is similar to the problem of image identification. Broadly speaking, we see first what we want and are ready to see, as it is in Maurits Escher´s lithographs. Let´s remember the play of imagination while scanning intricate forms of clouds. Partially, science is also not free from this play because people make it. We present arguments and explanations belonging to the whole historical arsenal of culture by means of which we were brought up, to scientific paradigms that we follow and to authorities that we trust. Very often a discovery that seems unimportant or wrong on the surface is neglected as methodical or indicated error. The number of those who could have, but did not become a Nobel Award winner is much larger than that of those who dared to think and see the world in a different way.

In conclusion, it is necessary to stress the limited character of breaking down the being and becoming of reality into pure forms. During the course of the latest decades, researchers have been studying systems where chaotic behavior is a norm, and where there is not a short period of anomalies or systemic crisis. First of all it is turbulence, climate models, plasma. It points to the overlapping of different hierarchical levels at the same observation scale, the presence of non-stability and chaos at the level of being – so called strange attractors, attractors with a chaotic component. I.e. it is necessary to differ between chaos of Being and chaos of Becoming. Examples of chaos of Being are the variety of life forms in the biosphere guaranteeing its stability; another one the presence of partial chaotic rhythms of a heart beat, which is a sign of a cardiovascular system´s good adaptability; the element of market spontaneity necessary for stability and so on. The image *Being is in Becoming* is quite appropriate for such systems.

Conclusion

Synergetics emerged as a theory of co-operative phenomena in laser studies. Gradually, it has been gaining the status of a more and more general theory describing non-closed, non-linear, non-stable, and hierarchical systems. In the sphere of the natural sciences, there is an opposition to such a treatment of synergetics. Some scientists prefer to speak of non-linear dynamics, dissipative systems theory, theory of open systems, theory of dynamic chaos, autopoiesis, etc. We think that synergetics can only be scientifically justified only after the inclusion of the observer, ′man-dimensional′ systems, self-referential systems, i.e. the widening of synergetics′ methodology to the holistic cultural sphere is necessary. Our own works are based on such a broad understanding of synergetics. Philosophically speaking, synergetics is a science (or a movement in science) of a Becoming Being, of Becoming itself, it′s mechanisms and their representation. And here it is important to avoid another extreme: not to be carried away by fashionable synergetical phraseology, it′s critical to stay on the positions of science, using its potential as technology realized in practical activities.

References:

Arshinov, Vladimir/Budanov, Vladimir (1994) *Synergetics: Evolutionary Aspect.* In: *Self-Organisation and Science: Experience of Philosophic Comprehension.* Moscow. Institute of Philosophy of the Russian Academy of Sciences. pp. 229 – 242 (in Russian).

Arshinov, Vladimir/Budanov, Vladimir/Voitsekhovich, Vyacheslav (1995) *Principles of Becoming Processes in Synergetics* In: *XI International Conference Logic, Methodology, Philosophy of Science.* Vol. VII. *Methodological Problems of Synergetics.* Moscow. Obninsk, pp. 3-5 (in Russian).

Arshinov, Vladimir/Voitsekhovich, Vyacheslav (1999) *Synergetical Knowledge: Between the Net and the Principles* In: *Synergetic Paradigm.* Moscow. pp.107 – 120 (in Russian, the English version can be found in this book).

Budanov, Vladimir/Melekhova, Olga/Suhanov, Aleksander (1995) *Exemplary program of the discipline "Conceptions of Modern Natural Science" for humanitarian fields of bachelors*. Edited by Academician Stepin, Vyacheslav. Moscow (in Russian).

Haken, Herman (1980) *Synergetics.* Moscow (in Russian).

Kurdyumov, Sergey/Knyazeva, Helena (1981) *Evolutionary Laws and Self-Organisation of Complicated Systems.* Moscow.

Prigogine, Ilya. (1984) *From Being to Becoming*. Moscow (in Russian).

Stepin, Vyacheslav (1992) *Philosophical Anthropology and Philosophy of Science*. Moscow (in Russian).

Synergetic Knowledge: Between the Network and the Principles*

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We interpret the knowledge on chaos and order, on transition processes and on fractals that is called synergetics, as a branch of science and as a world outlook (Weltanschauung) stemming from different images, facts and notions of chaos, order, coherence and transition and cooperative processes in nature, society and the inner world. As a result in scientific communities and adhering circles, different assessments of synergetics are voiced, ranging from romantically enthusiastic ones ("third millennium science") to strictly negative ones ("nothing new").

The sciences of philosophy are capable of giving a well-balanced assessment of the new science. They allow for the revelation of the specifics of synergetics, the formulation of its principles and the establishment of levels in the study of chaos and order.

Hermann Haken, the founder of synergetics, says: "Synergetics is engaged in the study of systems consisting of multiple subsystems of different origin, such as electrons, atoms, molecules, cells, neurons, mechanical elements, photons, units, animals and even human beings" . In his opinion, the main problem of synergetics is "if there exist any general principles guiding the rise of the self-organizing structures and/or functions". For Haken, synergetics is a theory of self-organizing systems (Haken 1996: 19,16).
Ilya Prigogine and his colleagues (G. Nicolis, P. Glensdorf, I. Stengers, etc.) point out another view of the problem. They are developing a theory of dissipative structures within the framework of time studies which allow them to arrive at a deeper understanding of synergetics as a new scientific world outlook (Nicolis/Prigogine 1989, Prigogine 1980, Prigogine/Stengers,1984).

Haken´s and Prigogine´s theories complement each other, both rediscover time and space concepts for within their own world outlooks. Haken demonstrates a space that is based on a specific gestalt, i.e. the phase transitions that are experienced by an observer going the Tao way. Prigogine demonstrates a temporal experience that is based on personal knowledge (just like Polani does). Time is not only a construction, but also a motive. The Belgian physicist links subjective time to physical time (like A. Bergson). As a result, both Haken and Progogine rediscover Einstein´s old dream – chronometry. But in their versions it is not based on stability, harmony, simplicity, but on instability, fractality, and complexity.

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Alongside the works of physicists (Haken, Prigogine, Klimontovich, etc.), a mathematical branch of the study of self-organising systems has been developed. The foundations were laid by A. A. Andronov, V. I. Arnold, and R. Thom whose works gave birth to the theory of bifurcation and catastrophe theory. In these works synergetics is interpreted as the science of the mathematical modelling of systems that move from one stable state to another.

According to S. P. Kurdjumov and E. I. Knyazeva, synergetics is a new scientific paradigm generating a revolution that is more subtle and larger than the scientific revolution that took place at the turn of the 20th century and started with the theory of relativity and quantum mechanics. Synergetics is based on systems thinking or, to be precise, on the idea of agreements about the world and the knowledge of the world, the general character of the development laws that apply for the objects of all levels of worldly organisation, on the idea of the non-linearity (multi-variant and irreversible character) of development and on a deep interaction of chaos and order (chance and necessity) (Knjaseva/Kurdjumov 1992).

The main ideas of synergetics are non-linearity, self-organisation and open systems. Synergetics was also considered by V. P. Bransky (1997). He identifies the following leading categories of synergetics: dissipative structures, bifurcation, co-operation, trajectories and attractors. This author discovers a set of similarities between Hegel´s philosophy and synergetics, the latter may also be called a theory of the emergence of new qualities. Bransky describes synergetics as a theory of the selective development of dissipative systems and is in accordance with Prigogine´s interpretation (see especially Nicolis/Prigogine 1989).

Bransky himself is engaged in developing a synergetic culturology – a concept that conceives the development of social systems as the movement towards a super-attractor (= an absolute ideal). Along with the works of physics, biologists, mathematicians and philosophers, theological concepts of self-organisation emerged that consider synergy as an energetic interaction between God and man (interchange of energy during passionate prayer). Such concepts are based on the ideas of Gr. Palama, a monk from Afon who lived in the 14th century and are developed within the framework of Orthodox theology (isichast tradition – silent prayer) (Synergy 1995, Voitsekhovich 1997).

In isiachasm, silence is understood as a passionate, wordless longing for God that is reached after many hours of verbal prayer. It is assumed that human energies (emotional, mental, spiritual ones) are united with God´s energy. From chaotic thoughts order would emerge as sacred silence. It must of course be mentioned that the object of such studies is heavily disputed within the scientific community.

Let´s recapitulate the main aspects of synergetics. Synergetics is considered as:
1. a paradigm – a system of ideas, principles, images and notions – that possibly will give birth to a fundamental scientific theory, or a general scientific theory or even a world outlook.
2. a number of particular scientific theories (in physics, chemistry, biochemistry, biology, sociology, psychology, etc.) that have common aspects such as non-linearity, openness, transience and inequality of the processes occurring within the systems.
3. a general scientific theory, i.e. a theory of dissipative structures (in the sense of Prigogine), or a theory of transient processes, of mutual transitions of chaos and order, etc.
4. a new world-outlook trying to overcome the now dominant scientific outlook that is based on conceptions such as stability and unchangeability. Such a new outlook is based on concepts such as becoming, transience, instability and fractals.

We consider synergetics optimistically as a new general scientific concept and a source of a new world outlook. It is possible to confirm the idea of a new general scientific theory by singling out its theoretical kernel (principles) and by demonstrating the presence of not only a descriptive and explanatory function of such a theory, but also of a forecasting function as well as by discovering the regions of verification and falsification for the theory in question.

From the point of view of a classic (pre-synergetic) methodology of science it is quite possible to distinguish three levels of synergetic knowledge: particular sciences, general science and philosophy (fig.1).

World outlook, Philosophy

General scientific theory (meta-theory)

Special scientific theories (object knowledge, experimental knowledge)

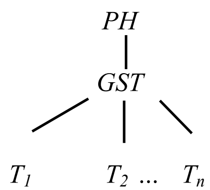

Fig. 1.: The Three Levels of Synergetic Knowledge.

Particular scientific theories have emerged by now (and are currently under construction) in laser physics, turbulence physics, in the theory of non-linear phenomena of chemical dynamics, in the theory of non-linear bio-evolution, in the theory of gene-cultural co-evolution (Ch. Lumsden and E. Wilson), and in social synergetics.

The next level of synergetic is the level of general scientific theory. It describes, explains and forecasts any instance of self-organisation. Such a theory also functions as a meta-theory, i.e. it explains and forecasts particular scientific theories. General synergetics is a meta-theory.

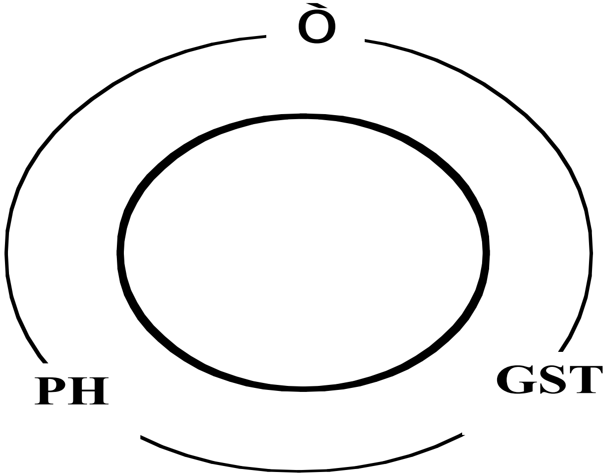

Fig. 2.: The Circle of Synergetic Knowledge

Last but not least there is the third level of synergetic knowledge – the philosophical one. At this level the elements of science are mixed with the elements of belief. In our view, such knowledge can´t be falsified. The lines shown in figure 1 mean ascending from the particular to the general and represent the linear way of thinking.

For non-linear synergetic thinking the relationships should be conceived in terms of "everything in all," "above as below". In a synergetic methodology "all levels are equal", thus the line should be depicted as a circle that dissolves the hierarchy immanent in figure 1. Hence in figure 2, all levels have equal importance, there is no no division of higher and lower levels. (in fig. 2, T stands for theory, Ph stands for the philosophy of synergetics, and GST stands for the General Scientific Theory).

Each of the three synergetic circle elements consists of various other elements. For example, T might represent a set of various physical,. chemical, biological and sociological theories. GST might represent an open web of several general scientific theories and concepts – Haken and Prigogine´s theories, aspects from mathematics and logics, vitalist and teleological concepts, etc. PH stands for more than one philosophy, it represents the whole domain of various scientifically treated outlook teachings that are rooted in Taoism, Buddhism, Hinduism, esotericism, Christianity, Pythagorism, Platonism, Aristotelism, as well as in the ideas of Cartesius, Leibniz, Kant, Hegel, Solovyov, Florensky, Heidegger, etc. This list shows the dialogical nature of synergetics.

Synergetic knowledge (comprised of facts, regularities, guesses, hypothesis, theories and philosophical teachings) should be conceived topologically as a multi-dimensional open network (fig. 3.).

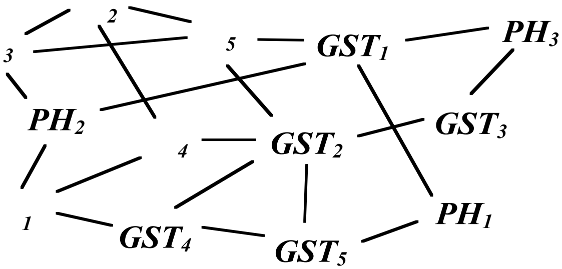

Fig. 3.: The Network of Synergetic Knowledge

A wave of agitation emerges in the network from time to time. It moves through the network activating (or giving birth to new) elements and slowing down others. The network functions as a discrete wave structure similar to the brain where particles (neurons) and waves complement each other according to the corpuscular wave of complementarity.

Synergetics is in search of its own language (Arshinov/Svirsky 1996). The foundations of this language are laid first of all by the principles that the particular scientific theories have in common as well as by the general scientific principles and by the main values ("pillars of belief") of the synergetic world outlook.

The principles of the particular scientific theories (object theories) differ naturally from each other due to the differences in subject domains. Nonetheless it is possible to single out principles that are common for all theories, and to point out specific features for physical, chemical, biological, sociological, psychological, etc. theories.

Arshinov/Budanov/Voitsekhovich (1995) distinguish four principles of particular synergetic theories:

1. Non-linearity: means the non-preservation of additivity in the development process of the represented systems. Any phenomenon is interpreted as an instance of evolution, as a process of movement within the field of development.
2. Instability: means the non-preservation of the "proximity" of the states of a system in its evolution.
3. Openness: means the system´s exchange of substance, energy and information with its environment, that a system consists of elements that are tied into a structure and that a system is part/element of another whole.
4. Subordination: means that the functioning and development of a system is determined by the processes in its subsystem (super-system) when a hierarchy of time scale appears. This could also be called the principle of the system´s self-simplification, i.e. there is a reduction of its dynamics to a small number of order parameters.

Principles that are specific for a certain object area such as the inorganic, living or human realm must be added to the four principles stated above. Thus, for inorganic (physical or chemical) systems a principle of non-locality (long-range action, long-distance correlation) is introduced. This principle means a certain interaction between the elements of the system that is treated as the transmission of information at infinite speed (see Bell 1964). For living systems (biological and to some extent technical systems) there is the principle of the bio-field: we assume that there is a singular field that unites the elements into a whole and directs the development of an organism towards predetermined prototypes (attractors). The notion of the bio-field is based on physicalism and vitalism and has been repeatedly introduced under various names. For example, there is the concept of the morphogenic field that was introduced in the twenties by the Russian biologist A. G. Gurvich. In the human realm there is a principle of transcendence or self, actualisation is introduced in order to specify the principle of non-linearity as the basic principle of synergetics. Transcendence means that the human being can go beyond the limits of every possible experience, can surpass himself, overcome the empirical ego, and achieve a confluence of the self and the cosmos.

Another constituent of the synergetic network are general scientific theories. There are two main aspects of GST: the contents and formal aspects. These two units together make up the methodology of synergetics.

The content unit is comprised of:

1. The principle of becoming: this principle states that the main form of being is not that what already is, but that what is becoming. Being is not stabile, statics, eternal, but transient, intermediate, temporary, not rest but change, not ended, eternal and statically-whole forms but transient, intermediate, temporary, and ephemeral-fractional.
Becoming is represented by its two extremities: chaos and order. Chaos is the foundation for complexity, contingency, creation-destruction, constructiveness-deconstructiveness. Order is the foundation for simplicity, necessity, law, beauty, and harmony. The interaction between chaos and order exposes the following images:
the image of time as the tempo of becoming, as the process of appearance and disappearance, as the periodic substitution of discrete, regulated structures by a "mess" of chaotic substance.
the image of subject, accomplishing a transition from potentiality to actuality that includes a complication of the modes of existence as shown by Aristotle in his teachings on form and matter. There are various levels of existence: a) chaotic matter, b) clay, stone, c) plant, d) animal, e) human being, f) God as the form of forms;
the image of freedom as the possibility of subjectivity in all that is thought and unthought, evident and secret, expressible and inexpressible; as the glorious feeling of the attainability of anything, as the desire for eternal life (game of chaos and order).

2. The principle of recognition means recognition (discovery) of existence as becoming. The order parameters have a dual role: they both advise the system´s behaviour and inform the observer about the macro features of the system. The recognition principle is a variant of the Sapir-Wharf linguistic relativity principle that says that every language has its own ontology.

3. The principle of accord is based on communication and dialogue. It says that being as becoming is formed and is recognised only during the course of a dialogue, of a communicative and friendly interaction of the subjects, as well as in harmony that results from this process. One of the sources of the accord principle is the principle of conventionality as formulated by Henri Poincaré.

3. The principle of correspondence allows a transition from pre-synergetic (classic, "non-classical" and "post-non-classical") science to synergetics.

4. The principle of complimentarity means the independence and partiality of both pre-synergetic (without the synergetic) and synergetic (without the pre-synergetic) descriptions of reality. Existence appears as stable in the one concept and as

becoming in the other one. Existence is both stable and becoming. The formal unit is comprised of the ideas and principles brought about by those theories of logic and mathematics that are in correspondence with the notions of existence as the eternal world of becoming.
The mathematical unit is made up by the theory of catastrophes[1], fractal geometry, the theory of probability, algorithm theory, the theory of cellular automata, intuitional mathematics and category theory (especially the topological unit dedicated to topos theory; see Goldblatt 1979, Voitsekhovich 1996).

Intuitionism, catastrophe theory and category theory allow the formulation of the following principles:

1. The principle of mathematical becoming: This principle accentuates the mathematicians´ persuasions that forms are transformable and that there is an inner guidance of the transformation from simplified to complex forms and backwards. Problems in construction were already the highest aesthetic achievements of mathematics in ancient times. The basic "constructability" of an object became a leading requirement for intuitionism and constructivism. The principle is most vividly expressed in the works of L. E. J. Brouwer (the founder of intuitionism), it is also an important aspect of the works of pre-constructivists such as H. Poincare, H. Weyl, and A. A. Markov (Jr.). Intuitionists and constructivists are convinced that there is a superfluousness of negation as a method of proof and they assume that an "affirmative" proof is sufficient. Thus there are attempts to create forms of mathematics without negation (G. Griss, see Heyting 1956: 149-151). Brouwer has more than once stated that life, art, music and mathematics are essentially the same thing (Panov, 1984). This means that Brouwer assumes that activity is the central feature of man.

The following principles adhere to the principle of becoming. Mathematical folklore, the theory of algorithms, the works of Kolmogorov on algorithmic complexity, the theory of probability, the theory of cellular automata and fractal geometry allow the formulation of the following principles:

2. The principle of complexity means the possibility of the enrichment in the process of becoming, i.e. the possibility for a growth of structural complexity (LS-

[1] We disagree with the opinion of R.Thom (one of the developers of catastrophe theory) that this theory bears no relation to synergetics. Einstein wrote that one shouldn´t listen to what the scientists say about their methodology, but that one should take a look at what they are doing (Thom 1970; *Self-organisation Concepts* 1994: 146f).

process according to Kurdjumov). This is connected with the idea of constructive (creative) chaos and chaos as an ocean of information. Only an active subject (a scientist) that creates new communicative parameters of order allows the realisation of more complex information about a system. Formal transformations of a system preserve the system´s level of complexity as well as the quality and quantity of information ("the complexity preservation law ").

Category theory helps us to identify another three that are connected to synergetics (Voitsekhovich 1992):

3. The principle of fractal homomorphism (general similarity) accentuates on the one hand the fundamental character not of *what* is reflected, but of *how* something is reflected, and on the other hand, the mutual similarity of fractional structures on any scale. Fractality is interpreted as both a subject and a means of research. In becoming, not elements, but structures are important. F. W. Lawvere was the first scientist who gave attention to this fact. He developed an axiom of categories without sets and arrived at classes without elements. These classes are analogous to the λ-calculus of A. Church (= a logic without variables). Fractal mathematics and fractal logic are based on these assumptions. Lawvere worked out a theoretical and categorical model that is based on a pair of functors, a functor of chaos and a functor of order. Lawvere was the first scientist after Brouwer who has been able to overcome Platonic classical mathematics and has created a fractal theory where the process of order transforming into chaos and vice versa is perpetual (Lawvere 1994).

4. The principle of liberation: Georg Cantor wrote: "The essence of mathematics is freedom". Liberation as a methodological principle means that in the process of the development of mathematics, the original object, such as a numeral, is freed of a lot of casual connections thrust upon it by matter and an alienated physical world. The object in the mind of scientists becomes more rectified, free and beautiful – it becomes "itself" (the natural number unfolds into a negative, irrational and hyper-complex number, algebraic systems into a transfinite row of Cantor – in the sense of actual infinity). Liberation as a foundation for the classification of the stages of the history of mathematics was conceived by S. Pincerle at the end of the 19th century (later his idea was taken up by J. Hadamard and A. N. Kolmogorov, see Voitsekhovich 1992).

In mathematical creation, freedom has always been tied to its dialectical twin – limitation (as yang and yin). A mathematician feels his "free object" intuitively, but in order to give definiteness to the object he should postulate: "∃!" (only one exists).

Mathematical becoming is essentially the process of the liberation of an object (that can be interpreted in both a platonic sense and non-platonically, for example in the sense of "freely becoming sequences" by Brouwer).

5. The principle of duality means the unity of the inner and the outer ("it is one") and is valid for the mathematics at the whole. It emerged from the symmetry of addition and multiplication of numbers, points and lines in planimetry, algebra and geometry, axiomatic and genetic (constructive) methods, etc. The principle became a powerful heuristic means of solving difficult problems and introducing profound hypotheses about the origin of space (for example in the works of P. A. Florensky). Duality is connected to complimentarity as well as to the principle of mathematical becoming, namely the idea of non-negation mathematics. The principle refers to positive thinking without negations. In intuitionism and constructivism the original object undergoes gradual transformations, but there is always only one object (there is no twin – its negation, as in classical mathematics where proof by contradiction exists).

The logical part of the general theory of synergetics (meta-theory) presents the meta-logic description, i.e. the concrete logic in each of the objective theories is independent, usually two-digit Aristotelian logic is used, but also probability logic, intuitive logic, the logic of fuzzy predicates, etc. can be employed (Thom 1970). The meta-logic comprises:

1. The principle of logical becoming implies the transferability of logic and reflects the process of the system´s becoming. Thus, the two-digit logic that describes the initial state of the object can be converted to one-digit logic when the system reaches its attractor.

2. The principle of fractality denotes the ability of logic to express intermediate "fractal" states of the evolving object. Such logic should be based on "fractal" ideas, judgments and conclusions. For example, in order to describe a caterpillar that is encompassed by a cocoon in fall and transforms into a butterfly in winter, it is necessary to introduce fractals that are based on intuition: on December 1st, there is something in the cocoon (2/3 of a caterpillar and 1/3 of a butterfly), on January 1st there is 1/2 of a caterpillar and 1/2 of a butterfly, etc. The principle of fractality is a principle of temporality, or of the multiplicity of times. It introduces external and internal time, the time of becoming and the time of being (see also Tarasenko 1998).

3. The principle of geometricity means the dependency of a concrete logic on an emerging situation that is reduced to geometry (mathematics). Aristotle wrote that essentially all logic is reduced to geometry. The specifics of each interval (between bifurcations) determine the corresponding logic. Categorical logic demonstrates this assertion to the highest degree.

4. The principle of local non-predictability means the impossibility of predicting a form of logic that is applicable after a bifurcation. The chaotic and accidental character of becoming leads to freedom and a dialogical character of thinking that strives to reflect the process of transition.

5. The principle of global uniqueness asserts that uniqueness (positive, non-negative) logic is the main logic for describing the process of becoming in general, as is reflected in the principle of mathematic becoming. Some observers hold that the uniqueness of movement from one attractor to another can´t be adequately grasped by western people, but by people from of a quite different culture or by a superhuman being. Thus, in the opinion of a number of logicians, theologians, and philosophers there uniqueness logic existed in some cultures of Ancient India (Loy 1988). Traces of these cultures can be found in the Veda and a number of other literary texts.

As is clear from the structure of a general scientific theory of synergetics, there are common aspects of its contents and its formal part. The main principles are the principles of becoming, freedom, dialogue (subject-to-subject interaction and harmonisation), fractality and complexity.

Besides the object theories (in physics, biology, etc.) and the meta-theory, synergetic knowledge consists of philosophy (see figure 1). In philosophy, synergetic knowledge reaches the highest level of universality. Such a philosophical level is currently emerging in the form of several rather vague teachings that have united various ideas, images, myths and experiences. The most interesting works (bearing at least some semblance to philosophy) come from people like Prigogine and his team, Haken, Kurdyumov, Capra, Nalimov, Budanov, and Laszlo.

The main ideas of them are non-linearity, becoming, chaos and order, the presence of the subject in becoming, the non-platonism of thinking, holism, teleology.

In conclusion we want to say once more that the synergetic outlook differs from classical paradigms of thinking because it features communicativity, and a continuous unfolding dialogue between platonic and non-platonic traditions in the context of the evolving human culture.

References:

Achromeeva, T. S./Kurdjumov, S. P./Malinetsky, G. G. (1985) *Non-stable structures World Paradoxes.* Moscow. Znanie (in Russian).

Akchurin, I. A. (1994) Self-organisation theory notional apparatus development. In: *Self-organisation and science: philosophical thinking attempts* Moscow. Argo. pp. pp. 80-97 (in Russian).

Arshinov, V. I./Budanov, V. G./Voitsekhovich, V. E. (1995) *Becoming process representation principles in synergetics*: In: *Proc. of the XI Int. Conference. Logic, Methodology*, *Philosophy of science*. Vol. VII Moscow. Obninsk. pp. 3-5 (in Russian).

Arshinov, V. I./Svirsky, Ja. I. (1996) *Language problems in post-non-classic science*. In: *Physics in system of culture.* Moscow: Institute of Philosophy of RAS. pp. 175-184 (in Russian).

Bell, J.S. (1964) *On the Einstein-Podolsky-Rosen paradox*. In: *Physics* 1, 3, pp. 195-200.

Bransky, V.P. (1997) Theoretical Foundations of Social Synergetics. In: *Petersburg sociology* 1, pp. 148-179 (in Russian).

Goldblatt, R. (1979) *Topoi. The categorial analysis of logic*. Amsterdam. North-Holland Publishing Company.

Haken, H. (1996) *Principles of brain functioning. A synergetic approach to brain activity*, *behavior and cognition*. Berlin. Springer.

Heyting, A. (1956) *Intuitionism.* Amsterdam. North-Holland Publishing Company.

Knjaseva, E. N./Kurdjumov, S. P. (1992) *Synergetics - new world-outlook: dialogue with I. Prigogine.* In: *Problems of philosophy*, 12 (in Russian).

Laszlo, E. (1991) *The age of bifurcation. Understanding the changing world*. Amsterdam. OPA.

Lawvere, F.W. (1994). *Cohesive toposes and Cantor´s «lauter Einsen»*. In: *Philosophia Mathematica.* Series III. V. II, pp. 5-15.

Loy, D. (1988) *Nonduality. A study in comparative philosophy*. London.

Nalimov, V.V. (1982) *Realms of the unconscious: The enchanted frontier*. Philadelphia, Pa.: ISI Press.

Nicolis, G./Prigogine, I. (1989) *Exploring complexity*. New York. Freeman.

Panov, M.I. (1984) *Methodological problems of intuitionistic mathematics*. Moscow. Nauka (in Russian).

Prigogine, I. (1980) *From being to becoming: time and complexity in the physical sciences.* San Francisco. W.H. Freeman and Company.

Prigogine, I./Stengers, I. (1984) *Order out of chaos.* London. Heinemann.

Self-organisation Concepts: Scientific Thinking,Foundation of New Images (1994) Moscow (in Russian).

Synergy. Orthodox ascetics and mystical problems (1995) Moscow. Di-Dik (in Russian).

Tarasenko, V. V. (1998) *Logical - methodological aspects of fractal concept*. Candidate of philosophical sciences´ thesis. Moscow. Institute of Philosophy of RAS (in Russian).

Thom, R. (1970). *Morphogenesis dynamic theory*. In: *In the direction of theoretical biology*. Moscow, pp. 145-157 (in Russian).

Voitsekhovich, V.E. (1992) *Mathematical theory formation (philosophical - methodological analysis)*. Doctor of philosophical science´ thesis. Moscow. Institute of Philosophy of RAS (in Russian).

Voitsekhovich, V.E. (1996) *Mathematical theories in synergetics.*In: *Stable development in a changing world.* Moscow Synergetic Forum*,* 1996, p. 46 (in Russian).

Voitsekhovich, V.E. (1997) *Synergetics and isihasm*. In: *Synergetics and psychology*. S. Petersburg, pp. 120-122 (in Russian).

II.2. Physical Systems

Dialectical Philosophy and Self-organisation

Christian Fuchs

Abstract

The aim of this paper is to show that the theory of self-organisation in some respect proves the topicality of dialectical materialism and that an alternative concept of substance makes sense within the framework of dialectical materialism. The first part of the paper shows that Marx and Engels opposed the notion of substance because for them this notion was connected with the assumption of mechanical materialism that there is an eternal, unchanging stuff in the world to which all existence can be reduced. An alternative concept of substance is implicitly present in Engels´ works because he says that the eternal aspect of the world is that matter is permanently changing and moving and producing new organisational forms of matter. Ernst Bloch has explicitly formulated this concept of process-substance within the framework of dialectical materialism and in opposition to mechanical materialism. Such an alternative conception of substance can as the second part of this paper shows also be expressed as the permanent and eternal self-organisation of matter. Concepts from self-organisation theory such as control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory correspond to the dialectical principle of transition from quantity to quality. What is called emergence of order, production of information or symmetry breaking in self-organisation theory corresponds to Hegel´s notions of sublation (Aufhebung) and negation of the negation. Self-organisation theory shows that Engels´ *Dialectics of Nature* is still very topical and that dialectical materialism contrary to mechanical materialism and idealism hasn´t been invalidated, it rather seems to be confirmed that dialectics is the general principle of nature and society.

1. Matter and Substance in Dialectical Materialism

Friedrich Engels has formulated some theses of a dialectical philosophy of nature that have remained very topical until today:

- The real unity of the world consists in its materiality (1878: 41)
- The basic forms of all being are space and time, and there is no being out of space and time (1878: 48).

- Motion is the mode of existence of matter. There is no matter without motion and no motion without matter. Both are uncreatable and indestructible (1878: 55)
- The human mind is the highest product of organic matter (1886a: 313; 1886b: 341).
- Nature does not just exist, but comes into being and passes away (1886a: 317), it has its existence in eternal coming into being and passing away, in ceaseless flux, in un-resting motion and change (ibid.: 320).
- Matter is eternally changing and moving, "we have the certainty that matter remains eternally the same in all its transformations, that none of its attributes can ever be lost, and therefore, also, that with the same iron necessity that it will exterminate on the earth its highest creation, the thinking mind, it must somewhere else and at another time again produce it" (1886a: 327).
- Nature forms a system, an interconnected totality of bodies which react on one another, this mutual reaction constitutes motion (1886a: 355)
- The basic form of all motion is approximation and separation, contraction and expansion – *attraction* and *repulsion* which are dialectical poles of movement (1886a: 356f).
- Matter is the totality of matters from which this concepts abstracts. Words like matter and motion are abbreviations[1], which combine many different, sensually perceivable things according to their common properties (1886a: 503). Matter is an abstraction in the sense that we abstract from the qualitative differences of things and combine them as physically existing in the concept of matter (ibid.: 519).

Matter is the totality of objects that constitute reality and is itself constituted in space and time by an interconnected totality of bodies which react on one another (motion), i.e. they repulse and attract each other. Motion is the mode of existence of matter in space-time. Matter is an eternal process of becoming and passing away, a ceaseless flux, it is uncreatable and indestructible. Matter is the totality of

[1] Also for Hegel, matter is an abstraction. He defines the Thing as the determined and concrete unity of Ground and Existence. It consists of matters or materials which are themselves partly things, which in that way may be once more reduced to more abstract matters. Numerous diverse matters coalesce into the one Matter. "Thus Matter is the mere abstract or indeterminate reflection-into-something-else, or reflection-into-self at the same time as determinate; it is consequently Thinghood which then and there is the subsistence of the thing. By this means the thing has on the part of the matters its reflection-into-self [...]; it subsists not on its own part, but consists of the matters, and is only a superficial association between them, an external combination of them" (Hegel 1874: §127).

objective, really existing systems that are interconnected and accord to different physical laws. Matter exists independently from human consciousness, the latter is a specific organisational type of matter. The material unity of the world means that the motion of matter results in a natural hierarchy of relatively autonomous forms of movement of matter where each level has new, emergent qualities that can´t be reduced to lower levels or an assumed "materia prima". Time is an expression of the irreversible changing state of matter. Movement in time means movement in space and vice versa. Both space and time express the permanence of change that is a fundamental property of matter. Matter permanently organises itself and produces an irreversible sequence of states.
Attraction and repulsion are the essence of matter (Hegel 1874: §§97f)[2], as polar opposites they are "determined by the mutual action of the two opposite poles on one another, [...] the separation and opposition of these poles exists only within their unity and inter-connection, and, conversely, [...] their inter-connection exists only in their separation and their unity only in their opposition" (Engels 1886a: 357).

Energy is mass in movement. Energy is also the measure of the capacity of a physical system to undergo change (Marquit 1980). The unity of attraction and repulsion forms a field that surrounds and influences particles. Matter and energy are two forms of one and the same thing, mass is condensed energy and energy radiated mass. Energy is not something external to matter, it is inherent to matter. Einstein has shown that energy and mass are equivalent, hence energy has mass and mass energy. This seems to prove the assumption of dialectical materialism that mass and energy are the same – Engels described energy as the mode of existence, the inherent attribute, of matter. Energy is produced and transmitted

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[2] "The One, as already remarked, just is self-exclusion and explicit putting itself as the Many. Each of the Many however is itself a One, and in virtue of its so behaving, this all rounded repulsion is by one stroke converted into its opposite – Attraction [...]. But the Many are one the same as another: each is One, or even one of the Many; they are consequently one and the same. Or when we study all that Repulsion involves, we see that as a negative attitude of many Ones to one another, it is just as essentially a connective reference of them to each other; and as those to which the One is related in its act of repulsion are ones, it is in them thrown into relation with itself. The repulsion therefore has an equal right to be called Attraction; and the exclusive One, or Being-for-self, suppresses itself. The qualitative character, which in the One or unit has reached the extreme point of its characterisation, has thus passed over into determinateness (quality) suppressed, i.e. into Being as Quantity" (Hegel 1874: §97f).

from one atom to another only in portions of a certain extent (quanta, Max Planck). The atom emits (or gains) energy as it moves from one stationary state to another. Energy is not emitted or absorbed in a continuous manner, but rather in small packets of energy called quanta. An atom moves from one energy state to another state in steps. The energy of a quantum depends on the frequency of radiation and Planck´s constant (E = f x h), or expressed another way the frequency of radiation can be described as $f = (M \times c^2)/h$. This also means that particles are fields and that a particle with a mass M is connected with a field of frequency $(M \times c^2)/h$. The complementarity relation (Niels Bohr) says that for each type of particle there is a corresponding wave-field. ”The laws of quantum mechanics fly in the face of ´common sense´ (i.e., formal logic), but are in perfect consonance with dialectical materialism” (Woods/Grant 2002: 103).

Bohr and Rutherford have shown that atoms are not the smallest parts of the world. In it we find electrons circling around the nucleus that consists of protons and neutrons that are themselves no elementary particles, but consist of quarks. Elementary particles (6 types of quarks, 6 types of leptones) are not an immoveable substance, they are transforming themselves. The stuff our world is made of are atoms, pure materials or elements. We know 118 pure materials (periodic table). They combine and form molecules that have new qualities. Radioactivity and quantum theory don´t mean the “disappearance of matter”. Particles and energy are both structural forms of matter. Elementary particles seem to disappear and reappear, they can´t be considered as changeless substance, but as Erwin Schrödinger said they are “more or less temporary entities within the wave field whose form and general behaviour are nevertheless so clearly and sharply determined by the laws of waves that many processes take place as if these temporary entities were substantial permanent beings“ (Schrödinger 1953: 16).

These physical conceptions such as Heisenberg´s conception of the field as the source of particles, the assumption of quarks as elementary particles etc. show that the source of existing forms of matter is itself material and that the unity of the world is its materiality (Hörz 1976)[3]. Mechanical materialism has been invalidated by modern physics, but not so dialectical materialism. The latter´s assumption that the world is in constant flux and process-like has been asserted. Engels basic

[3] “The process of continual change which characterizes the world at the subatomic level is a striking confirmation of the fact that dialectics is not just a subjective invention of the mind, but actually corresponds to objective processes taking place in nature. This process has gone on uninterruptedly for all eternity. It is a correct demonstration of the indestructibility of matter – precisely the opposite of what it was meant to prove” (Woods/Grant 2002: 105).

hypotheses about the dialectics of matter still remain topical. Complementarity doesn´t mean a dualistic, but a dialectical relationship of wave and particle.

Certain subjectivist interpretations of the uncertainty principle (impossibility of exactly measuring position and momentum of an electron at the same time), the theory of relativity and the Copenhagen interpretation of quantum mechanics hold that the world only exists and is real when we observe it. The thought experiment by Erwin Schrödinger known as "Schrödinger´s cat" shows the absurdity of such idealist assumptions and illustrates that the world exists independently of our observation (although it surely can be observed in different ways and on different levels; and observation can change reality[4]).

In quantum mechanics the psi-function is a means for predicting the probability of measurement results, it is determined by a finite number of suitably chosen measurements on the object, half as many as were required in the classical theory. Schrödinger introduces the example of the cat in order to show that a purely subjectivist interpretation of quantum mechanics results in ridiculous and paradoxical cases. "A cat is penned up in a steel chamber, along with the following device (which must be secured against direct interference by the cat): in a Geiger counter there is a tiny bit of radioactive substance, *so* small, that *perhaps* in the course of the hour one of the atoms decays, but also, with equal probability, perhaps none; if it happens, the counter tube discharges and through a relay releases a hammer which shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives *if* meanwhile no atom has decayed. The psi-function of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts" (Schrödinger 1980).

Energy and information don´t exist outside of or external to matter, they are specific aspects of the movement and development of matter and as such are integral aspects of the world.

In Ionian philosophy there was the idea of prime matter. For Thales the prime matter (Urstoff) was water, for Anaximander "apeiron", for Anaximenes air, for Heraklit fire. The Atomists Demokrit and Leukipp reduced all being to smallest

[4] The appearance of phenomena such as distance, speed, luminance, time, space, etc. depends on the position of the observer, but this doesn´t mean that the essence of material reality is determined by observation. There is in fact a difference between essence and appearance. Material reality is infinite and constantly changes, it also exists outside of human observation. If human observers are absent, there still is the motion of matter in space-time.

parts of the world that are not dividable, move spontaneously and join or repel when colliding. From them there are eternal and indestructible corpuscles. The cosmos is seen as a system that is structured by the collision of atoms, the atoms themselves are considered as substance that doesn´t change. These early positions can be considered as materialist monism.

Aristotle who tried to combine Ionian materialism and Elatic idealism postulated that substance always remains the same, nothing becomes or passes away, the same nature always maintains itself. For Aristotle there is substance (essence) and accident (contingency), hyle (substance) and eidos (form). Form and substance are two aspects of a thing that can´t be divided, the only form without substance would be God. His position is one of ontological dualism, besides material being there is immaterial being.

The Middle ages were dominated by a religious conception that considered matter as a creation of God. This was questioned by Pantheistic conceptions such as the one of Giordanno Bruno that considered God as an eternal force that is immanent in nature. The Newtonian world-view was characterised by its believe in absolute immutability of nature and a reductionistic methodology. Nature was considered as a conservative system that remains stabile from its beginning until its end, organic matter was reduced to mechanics. French materialism of the 18th century (LaMettrie, Holbach, Diderot, Helvétius, Condillac, Alembert, Condorcet, Bonnet, Robinet, Laplace) as well as the "mechanical materialists" (Engels 1886b: 342) of the 19th century (Moleschott, Büchner, Vogt) were influenced by this worldview. The human being was considered a machine and the universe wasn´t comprehended "as a process, as matter undergoing uninterrupted historical development" (Engels 1886b: 342). Relatively autonomous objective systems with higher forms of motion were reduced to mechanical ones.

Marx, Engels as well as Hegel (the latter remained trapped in irrational thinking, although he revolutionised philosophical methodology) were highly critical of the Newtonian worldview. They emphasised interconnection and processes instead of singularities and reduction. Hegel criticised atomistic philosophies (Hegel 1874: §§ 97, 98) by saying that they fix the One as One, the Absolute is formulated as Being-for-self, as One, and many ones. "It doesn´t see that the One and the Many are dialectically connected: the One is being-for-itself and related to itself, but this relationship only exist in relationship to others (being-for-another) and hence it is one of the Many and repulses itself. But the Many are one the same as another: each is One, or even one of the Many; they are consequently one and the same. As those to which the One is related in its act of repulsion are ones, it is in them thrown into relation with itself and hence repulsion also means attraction".

Marx criticised the reductionism of individualism in his critique of Max Stirner (Marx/Engels 1846: 101-438) and put against this the notion of the individual as a social being that is estranged in capitalism and can only become a well-rounded individual in communism (see Fuchs/Schlemm 2002). Engels criticised the reductionism and individualism of “metaphysical thinkers”: “To the metaphysician, things and their mental reflexes, ideas, are isolated, are to be considered one after the other and apart from each other, are objects of investigation fixed, rigid, given once for all. He thinks in absolutely irreconcilable antitheses. "His communication is ´yea, yea; nay, nay´; for whatsoever is more than these cometh of evil". For him a thing either exists or does not exist; a thing cannot at the same time be itself and something else. Positive and negative absolutely exclude one another, cause and effect stand in a rigid antithesis one to the other“ (Engels 1878: 20f). “Hard and fast lines are incompatible with the theory of evolution. [...] For a stage in the outlook on nature where all differences become merged in intermediate steps, and all opposites pass into one another through intermediate links, the old metaphysical method of thought no longer suffices. Dialectics, which likewise knows no hard and fast lines, no unconditional, universally valid ´either…or´ which bridges the fixed metaphysical differences, and besides ´either…or´ recognises also in the right place ´both this – and that´ and reconciles the opposites, is the sole method of thought appropriate in the highest degree to this stage“ (Engels 1886a: 482).

Self-organisation theory today also stresses the interconnectedness and process-structure of the world and criticises reductionism. Also Ilya Prigogine and Isabelle Stengers, the founders of dissipative systems theory, stress that Hegel and Marxism are important process-thinkers: “The Hegelian philosophy of nature systematically incorporates all that is denied by Newtonian science. In particular, it rests on the qualitative difference between the simple behavior described by mechanics and the behavior of more complex entities such as living beings. It denies the possibility of reducing those levels, rejecting the idea that differences are merely apparent and that nature is basically homogenous and simple” (Prigogine/Stengers 1984: 89). “The idea of a history of nature as an integral part of materialism was asserted by Marx and, in greater detail, by Engels. Contemporary developments in physics, the discovery of the constructive role played by irreversibility, have thus raised within the natural sciences a question that has long been asked by materialists. For them, understanding nature meant understanding it as being capable of producing man and his societies” (Prigogine/Stengers 1984: 252).

Marx and Engels opposed the idea of substance (an endless, changeless carrier of changing qualities[5]) as materia prima because they considered such positions as mechanical and undialectical, neglecting that matter is always in motion and in its dialectical process of becoming develops higher organisational levels. Hence if one takes a look at the history of dialectical materialism one will find an animosity towards the notion of substance. E.g. Lenin wrote: “The recognition of immutable elements, “of the immutable substance of things,” and so forth, is not materialism, but *metaphysical, i.e.,* anti-dialectical, materialism“ (Lenin 1952: 251). Herbert Hörz (1976: 222ff), one of the main philosophers of the GDR, argued that due to field physics, the discovery of radioactivity, relativity theory and quantum theory, the notion of substance has become untenable. Modern physics has shown that elementary particles are transformed into other ones, the existence and maintenance of a particle is only possible in relationship to other particles and the latter´s qualities. Hence the idea of an unchangeable carrier of qualities seems no longer to be valid. “Whereas the notion of substance presupposes a changeless carrier, […] modern physics conceives material events primarily as change, interaction and searches for the structural laws of this change” (Hörz 1976: 225). The notion of substance wouldn´t be able to show the dialectical relationship of particle and field that was introduced by quantum theory. Field and elementary particles wouldn´t be substance because they aren´t changeless.

Hegel opposed the notion of substance for other reasons: Spinoza sees substance as causa sui, it is its own reason, Hegel says that such an assumption would exclude the creation of the world by God that he believed in. “A deeper insight into nature reveals God as creating the world out of nothing. And that teaches two things. On the one hand it enunciates that matter, as such, has no independent subsistence, and on the other that the form does not supervene upon matter from without, but as a totality involves the principle of matter in itself“ (Hegel 1874: §128, see also §§150f).

Due to modern physics a mechanistic and reductionistic conception of substance must be repudiated. Nonetheless there seems to be an alternative conception of substance immanent in Engels´ works on nature themselves: The substance of the world, i.e. that which exists permanently and endlessly, is the process-structure of matter. Matter is unresting, in permanent motion, in ceasless flux and a self-producing entity. In its dialectical movement it produces different organisational levels that have higher, emergent qualities which can´t be reduced to older

[5] Also Kant assumed a permanence of substance and said that “throughout all changes in the world *substance* remains, and that only the *accidents* change“ (Kant 1787: 214)

qualities. Rainer Zimmermann (1999) shows that such a materialistic conception of substance can be traced back to the line of thought constituted by Benedictus de Spinoza – Friedrich Wilhelm Schelling – Ernst Bloch. And it seems apparent that also Karl Marx and Frederick Engels seem to fit into this line as is e.g. shown by Engels´ assumption that matter is a producing entity and through its permanent flux and motion "remains eternally the same in all its transformations".

Other than in the reductionistic worldview that saw nature as enemy and tried to reduce all forms of being to a stabile and unmoving matter, Giordano Bruno, Spinoza and Schelling considered nature as a producing and process-like entity. Ernst Bloch sees this line as a historical alternative to the "block"-matter and the "root-thinking" of mechanistic materialism (Bloch 2000: 166ff). In opposition to the standard-assumption of their times that matter was created by God, these philosophers insisted that nature has its own reason and is producing itself.

The Marxist philosopher Ernst Bloch worked out an alternative conception of substance and matter within the framework of dialectical materialism (for details see Zeilinger 2002). In opposition to mechanical materialism[6] Bloch argues that matter is process-like, it is not a "dead block, moved only by pressure and push and remaining itself all the time" (Bloch 1963: 230), but nonetheless he doesn´t give up the notion of substance. Matter for Bloch is fermenting and process-like (Bloch 1963: 203), it is a process-being, being-in-possibility (dynamei on; 1963: 207) and has a historical-dialectical character (1963: 209). Matter as clade would be the fermenting sapling (gärender Schoss) of a substance that is bearing, developing, clarifying, qualifying itself (Bloch 2000: 173). Motion in its full extent would be the form of existence of matter: motion, change, production, tendency and latency (2000: 176).

Not-Yet characterises the tendency of material processes, as the origin that is processually emerging and tending towards the manifestation of its content (1963: 219). The Novum (see Bloch 1963: 227ff; 1975: 141ff) is grounded in the real possibility of a Not-Yet-Having-Become, it is the land of perspectives of the process itself, something that has never been and is real future. As such, it is never completely new. The novum opens up the possibility of "active hope", but it is not necessarily "a good one", it can cause "fear as well as hope", it includes the "double-possibility of crash and rise". It is a "moment of could-become-other" (Anderswerdenkönnen) in objective-real possibilities, one could say one of relative

[6] Bloch says that mechanical materialism has a concept of matter that is only analytical and static, it doesn´t know history, perspective and horizons of transformation (Bloch 1963: 208).

chance. Matter both contains tendency and latency (Bloch 1975: 144ff). Tendency means relative determination and necessity in the development-process of the world, latency is a force which drives the process towards a goal and forms spontaneously new structures. Latency drives towards a novum. Tendency in contrast to laws is undecided, for its decision it is in need of a "subjective factor", it has room for chance and the novum. Latency means an open, broad plurality. In latency, tendency has its pre-existence of its direction and its anticipation.

Bloch´s concept of matter anticipated the modern theories of self-organisation which also stress the productivity of matter that results in different organisational forms and hierarchical levels of matter and the self-reproduction and re-creativity of self-organising units. Nature is for Bloch a producing subject, he says it is forming itself, forming out of itself (1963: 234). In this context Bloch takes up Spinoza´s concept of natura naturans in order to stress that nature is not only passively produced, it is also itself an actively producing system. The relationship of tendency and latency in matter also reappears as a dialectic of chance and necessity in self-organisation theory (the concepts of relative chance by Kolmogorow and Chaitin and of incomplete determinism). What Bloch calls a novum is called emergent qualities in the sciences of complexity. Bloch used the term "emergence" himself by stressing that all gestalt figures *emerge* from the dialectical process and from matter as developing, producing (ausgebären[7]) substance immanently as well as speculatively (Bloch 1975: 165). For Bloch matter is a dialectically developing, producing substance.

Substance for Bloch is *process-substance* (1975: 246), it opens up possibilities, is fermenting and actively producing. It is "germ and utopian totum of the materia ultima in the laboratory of the world" (ibid.). Such a concept of substance seems to be an alternative to the "passive block-" and "root-"substance of mechanical materialism. Bloch explicates such an understanding, whereas it was implicitly present in Engels´ works who didn´t speak of substance, but about the eternal self-transformation and dialectical movement of matter.
Bloch stresses the important role of the human being in the self-transformation of matter. An organisational form of matter that would guarantee freedom and happiness would ultimately depend on human activities. Also Marx was interested in the relationship of man and nature and like Bloch considered the man-nature-totality as a self-organising system. In his *Economic-Philosophical Manuscripts* he stresses that in the production of his life which includes the metabolism between

[7] the German term used by Bloch is "ausgebären" which corresponds on the one hand to "bearing", but not only points at an active production, it also refers to a developing process

society and nature and social reciprocity, man as the universal, objective species-being produces an objective world (gegenständliche Welt) and reproduces nature and his species according to his purposes. He says that "nature is man´s inorganic body – that is to say, nature insofar as it is not the human body. Man lives from nature – i.e., nature is his body – and he must maintain a continuing dialogue with it is he is not to die. To say that man´s physical and mental life is linked to nature simply means that nature is linked to itself, for man is a part of nature" (Marx 1844a: 515f). Marx says that animals only produce their immediate needs, whereas man as the universal, objective species-being through production and the dialogue with nature not only produces himself, he also "reproduces the whole of nature" (ibid.: 516). So also for Marx human activity is decisive for the self-reproduction and self-transformation of the man-nature-system. Exploitation and estrangement in capitalism would result in a destruction of this system and hence Marx argues (just like Bloch did 100 years later) that the sublation of this social formation is a necessary condition for the true appropriation of man´s nature. "This communism, as fully developed naturalism, equals humanism, and as fully developed humanism equals naturalism" (Marx 1844a: 536). Bloch adds that a "good novum" would mean "materialisation of the human being, humanisation of matter" (Bloch 2000: 176).

2. Self-organisation and Dialectics

Saying the substance of the world is the permanent dialectical movement of matter and its self-productivity, corresponds to saying that matter organises itself and nature is a self-organising system. Wolfgang Hofkirchner (1993) has stressed that the new results of scientific research have been anticipated by Marx and Engels and that the concept of dialectical development re-enters science with self-organisation theory (see also Hofkirchner 1998)[8].

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[8] „Prima facie mag es ketzerisch anmuten, just in dem Augenblick, in dem mit der Abdankung der bisher einzig real versuchten Sozialismen marxistisches Denken von der Realität überholt worden zu sein scheint, annehmen zu wollen, dass die Ergebnisse der naturwissenschaftlichen Forschungen seit den Tagen von Marx und Engels im Detail eigentlich nur nachgeholt hätten, was diese mit ihrer Natur und Gesellschaft umgreifenden Entwicklungskonzeption philosophisch vorweggedacht hatten. Tatsächlich aber ist es gerade der Entwicklungsgedanke, der mit den neueren Theorien in alle naturwissenschaftlichen Disziplinen spontan hereinbricht, während er sich auf dem Gebiet der Gesellschaftswissenschaften diskreditiert hat, als er zur stalinistisch-kommunistischen Eschatologie einer vorgeblich linearen und unvermeidlichen Abfolge fünferlei Gesellschaftsordnungen verkommen war – zu

The theory of self-organisation has lead to a change of scientific paradigms: from the Newtonian paradigm to the approaches of complexity. There is a shift from predictability to non-predictability, from order and stability to instability, chaos and dynamics; from certainty and determination to risk, ambiguity and uncertainty; from the control and steering to the self-organisation of systems, from linearity to complexity and multidimensional causality; from reductionism to emergentism, from being to becoming and from fragmentation to interdisciplinarity. This has been interpreted as a shift from modern to post-modern knowledge (Best/Kellner 1997).

Concepts of physical self-organisation have been put forward by Ilya Prigogine´s theory of dissipative systems (Nicolis/Prigogine 1989, Prigogine 1980), Hermann Haken´s (1978, 1983) synergetics and Manfred Eigen´s hypercycle-theory (Eigen/Schuster 1979).

Principles of physical self-organisation are (see Fuchs 2001, Ebeling/Feistel 1994):

1. *control parameters*: a set a parameters influences the state and behaviour of the system
2. *critical values*: if certain critical values of the control parameters are reached, structural change takes place, the system enters a phase of instability/criticality
3. *fluctuation and intensification*: small disturbances from inside the system intensify themselves and initiate the formation of order
4. *feedback loops, circular causality*: there are feedback loops within a self-organising system; circular causality involves a number of processes p_1, p_2, …., p_n ($n \geq 1$) and p_1 results in p_2, p_2 in p_3, …. , p_{n-1} in p_n and p_n in p_1.
5. *non-linearity*: in a critical phase of a self-organising systems, causes and effects can´t be mapped linearly: similar causes can have different effects and different causes similar effects; small changes of causes can have large effects whereas large changes can also only result in small effects (but nonetheless it can also be the case that small causes have small effects and large causes large effects).
6. *bifurcation points*: once a fluctuation intensifies itself, the system enters a critical phase where its development is relatively open, certain possible paths of development emerge and the system has to make a choice. This means a dialectic of necessity and chance. Bifurcation means a phase transition from stability to instability.
7. *selection*: in a critical phase which can also be called point of bifurcation, a selection is made between one of several alternative paths of development

einem Schematismus, der mit der ursprünglichen Marxschen Theorie der gesellschaftlichen Entwicklung nichts zu tun hatte“ (Hofkirchner 1993: 7f).

8. *emergence of order*: in a critical phase, new qualities of a self-organising system emerge; this principle is also called order from chaos or order through fluctuation. A self-organising system is more than the sum of its parts. The qualities that result from temporal and spatial differentiation of a system are not reduceable to the properties of the components of the systems, interactions between the components result in new properties of the system that can´t be fully predicted and can´t be found in the qualities of the components. Microscopic interactions result in new qualities on the macroscopic level of the system. Checkland (1981: 314) defines an emergent quality in similar terms "as a whole entity which derives from its component activities and their structure, but cannot be reduced to them".
9. *information production*: new qualities of a self-organising system emerge and have certain effects, i.e. a complex reflective relationships is established between the trigger of self-organisation (the reflected), the emergent qualities (the result of reflection) and the function the new qualities fulfil for the system in its adaptation to its environment. We have defined this relationship as information, self-organising systems are information-producing systems, information is not a pre-existing, stabile property of a complex system
10. *fault tolerance*: outside a critical phase, the structure of the system is relatively stable concerning local disturbances and a change of boundary conditions
11. *openness*: self-organisation can only take place if the system imports entropy which is transformed, as a result energy is exported or as Prigogine says dissipated
12. *symmetry breaking*: the emerging structures have less symmetry than the foundational laws of the system
13. *inner conditionality*: self-organising systems are influenced by their inner conditions and the boundary conditions from their environment
14. *relative chance*: there is a dialectic of chance and necessity in self-organising systems; certain aspects are determined, whereas others are relatively open and according to chance
15. *complexity*: the complexity of a system depends on the number of its elements and connections between the elements (the system´s structure). There are three levels of complexity: 1. there is self-organisation and emergence in complex systems, 2. complex systems are not organised centrally, but in a distributed manner; there are many connections between the system´s parts, 3. it is difficult to model complex systems and to predict their behaviour even if one knows to a large extent the parts of such systems and the connections between the parts

One example of physical self-organisation are the Bénard-cells: A special liquid is heated at a certain temperature t2 from beneath and cooled down at a certain temperature t1 from above. So there is a temperature-difference Δt = t2 – t1 which develops and is the control parameter of the system (principle 1). At Δt = 0 the system is in equilibrium, the temperature gradient rises and at a certain critical value (p2), a new pattern emerges in the liquid that looks like honeycombs (p8, p9). The liquid particles are located in layers, lower layers are due to the temperature warmer than upper ones, they expand and their density decreases. At the beginning of the critical phase, a first small fluctuation is caused which means that a particle is thrown out of its position in a certain layer and enters an upper or lower layer (p3). It is not predetermined in which layer this fluctuation will occur. Fluctuations only take place if a certain threshold of the control parameter Δt is crossed. The fluctuation intensifies itself (p3), more and more liquid particles are detached from their stationary position, disorder, chaos and motion shows up (p6). The liquid particles arrange in cells that have different forms (round, square, broad, thin, large, small etc.). These forms are dependent on modes, which are elementary forms of motion. At a certain point of time, several types of cells exist. Finally one type can assert itself, there is one dominant form due to a selection process within the system (p7). As a result of the superimposition of many of the same form, a pattern emerges that looks like a honeycomb (p8, p9). So from an initial chaos of particles, order has emerged. At a certain value of the temperature gradient, this order disappears. In this process, it is determined that order will emerge, that there will be initial fluctuations which spread out and that one of several types of roles will be selected. But it is not determined in which layer the fluctuation will be caused, how the cell-types will exactly look like and which one will be selected (p14). This experiment will only be successful if energy in the form of a temperature difference will be applied to the system (p11).

Another example that is frequently used in order to explain self-organisation, is the functioning of a laser (see Haken 1987). A laser consists of an active medium that is situated between two mirrors. This medium is either a gas that is radiating due to the discharge caused by current entry or a crystal that is pumped through a flash lamp (e.g. a ruby with chrome ions can be used). The atoms of the crystal are stimulated by the flashes and an electron changes its trajectory, it jumps from an inner trajectory to an outer one and takes up energy from the flash lamp. It spontaneously returns to its former trajectory and emits energy in the form of a light wave. So due to the stimulation of the atoms caused by the flash lamp, the atoms emit light waves. The two mirrors again and again reflect the light. First there is a chaos of light waves. A light wave can hit other atoms and force them to intensify its own light. By such processes, the light waves reach certain amplitudes. Hermann Haken says that one light wave “enslaves” the others, this means that it becomes dominant and orders the system. As a result an ordered light wave, the laser beam, emerges. From a chaos of light waves an ordered pattern emerges (p8, p9). The decisive control parameter is current supply (p1, p11), the system can only enter criticality if the current reaches a certain threshold (p2). A light wave is caused by a fluctuation, i.e. an electron returns to its inner trajectory and emits energy; a light wave can intensify itself by "enslaving" electrons (p3). Such an intensification always means circular causality, because an entity causes the behaviour of another entity and this behaviour results in a transformation of the first entity (p4). Due to such intensifications, the system enters a state of chaos/instability/bifurcation (p5, p6). A certain light wave is selected (p7) and determines the emergence of the laser beam (p8, p9). It is determined that a laser beam will emerge, that fluctuations and intensification will be caused; but it is not determined how this exactly takes place and which light wave will order the system (p14).

Georg Wilhelm Friedrich Hegel has outlined that the purpose of dialectics is "to study things in their own being and movement and thus to demonstrate the finitude of the partial categories of understanding" (Hegel 1874: Note to §81). Self-organisation refers to the forms of movement of matter and hence is connected to dialectics. What is called control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory (principles 1, 2, 3, 5, 6, 7) corresponds to the dialectical principle of transition from quantity to quality. This is what Hegel has discussed as the Measure (Hegel 1874: §§107ff): The measure is the qualitative quantum, the quantum is the existence of quantity. "The identity between quantity and quality, which is found in Measure, is at first only implicit, and not yet explicitly realised. In other words, these two categories, which unite in Measure, each claim an independent authority. On the one hand, the quantitative features of existence may be altered, without affecting its quality. On the other hand, this increase and diminution, immaterial though it be, has its limit, by exceeding which the quality suffers change. [...] But if the quantity present in measure exceeds a certain limit, the quality corresponding to it is also put in abeyance. This however is not a negation of quality altogether, but only of this definite quality, the place of which is at once occupied by another. This process of measure, which appears alternately as a mere change in quantity, and then as a sudden revulsion of quantity into quality, may be envisaged under the figure of a nodal (knotted) line" (ibid.: §§108f).

What is called emergence of order, production of information or symmetry breaking in self-organisation theory (principles 8, 9, 12) corresponds to Hegel´s notions of sublation (Aufhebung) and negation of the negation. Something is only what it is in its relationship to another, but by the negation of the negation this something incorporates the other into itself. The dialectical movement involves two moments that negate each other, a somewhat and an another. As a result of the negation of the negation, "something becomes an other; this other is itself somewhat; therefore it likewise becomes an other, and so on ad infinitum" (Hegel 1874: §93). Being-for-self or the negation of the negation means that somewhat becomes an other, but this again is a new somewhat that is opposed to an other and as a synthesis results again in an other and therefore it follows that something in its passage into other only joins with itself, it is *self-related* (§95). In becoming there are two moments (Hegel 1812: §176-179): coming-to-be and ceasing-to-be: by sublation, i.e. negation of the negation, being passes over into nothing, it ceases to be, but something new shows up, is coming to be. What is sublated (aufgehoben) is on the one hand ceases to be and is put to an end, but on the other hand it is preserved and maintained (ibid.: §185). In dialectics, a totality transform itself, it is self-related. This corresponds to the notions of self-production and circular causality. The negation of the negation has positive results, i.e. in a self-organising system the negation of elements results in positive new qualities.

The two examples mentioned above in fact are examples of the dialectical development of matter. When the control parameters reach a certain threshold, a point of bifuraction or criticality, Hegel says a nodal-line, shows up. The quantities that are increased and transform into quality are the temperature gradient and electric current. The emergence of a pattern of honeycombs and of the laser beam means sublation and negation of the negation. The old state of the systems is eliminated, but nonetheless preserved in new qualities. New qualities show up and hence the systems reach a higher level.

The principle of relative chance that is typical for self-organising systems had already been considered as dialectic of chance and necessity by Hegel, Marx and Engels (Hegel 1874: §§144ff, Engels 1886a: 486-491). Engels has stressed that the dialectic of attraction and repulsion is an aspect of matter and its movement. Both elements are also described by self-organisation theory: Chaos, noise or instability are described as disordered movement of the elements of a complex system. One can also say that the elements are repulsing each other. But this repulsion is one that turns into attraction, because the elements interact, there are processes of ordering and selection, i.e. attraction takes place as the emergence of a coherent whole and new qualities.

As an example for the transition from quantitiy to quality Engels mentions the homologous series of carbon compounds:
"Here therefore we have a whole series of qualitatively different bodies, formed by the simple quantitative addition of elements, and in fact always in the same proportion. This is most clearly evident in cases where the quantity of all the

elements of the compound changes in the same proportion. Thus, in the normal paraffins C_nH_{2n+2}, the lowest is methane, CH4, a gas; the highest known, hexadecane, $C_{16}H_{34}$, is a solid body forming colourless crystals which melts at 21° and boils only at 278°. Each new member of both series comes into existence through the addition of CH2, one atom of carbon and two atoms of hydrogen, to the molecular formula of the preceding member, and this quantitative change in the molecular formula produces each time a qualitatively different body" (Engels 1878: 119).

Nodal lines or the transition from quantity to quality is today also studied in self-organisation theory. Especially the theory of self-organised criticality (SOC) (Bak 1996) focuses on this. It studies phenomena where perturbations that normally have small effects have large effects in a critical situation and push the system into chaos. A frequently mentioned example is a pile of sand. Dropping grains of sand onto each other will result in a pyramid. When the pile reaches a certain critical point, there is the possibility that just one additional grain results in the avalanching collapse of the whole pile. In a phase of SOC, the effects of one additional element vary from small to large, either pushing the system into chaotic behaviour or locking it into a fixed behaviour. The system is on the "edge of chaos". One feature that characterises SOC-systems is a power law distribution of the characteristic events such as avalanches, quakes, crashes, etc.: The average frequency of the event is inversely proportional to some power of its size: log (F) = – log (M). The log of the frequency of events is a linear function of the log of their magnitudes. The theory of SOC assumes that SOC patterns can be found e.g. in wars, wildfires, stock prices, traffic jams, international conflicts, and the collapse of society (Brunk 2002).

Almost everywhere in chemistry one can find examples for the transition from quantity to quality, therefore Engels speaks of chemistry as "science of the qualitative changes of bodies as a result of changed quantitative composition" (Engels 1886a: 351). This transition is what today is called in self-organisation theory emergence[9]. In a self-organising system, a certain threshold of a control parameter is crossed and order emerges. What is today called a point of

[9] Geoffrey Hodgson (2000: 65) points out that the concept emergence was anticipated by the philosophies of Hegel and Marx/Engels: "The terms ´emergence´ and ´emergent property´ date from the last quarter of the nineteenth century. However, the general idea behind these terms is older. It is redolent, for example, oft he ´law of the transformation of quantity into quality´ laid down by G.W.F. Hegel in his *Logic* and subsequently taken up by Karl Marx and Frederick Engels".

bifurcation, instability or criticality, Engels refers to as “Hegelian nodal line of measure relations – in which quantitative change suddenly passes at certain points into qualitative transformation“ (Engels 1878: 117) or even directly anticipating the modern terminology he speaks of “critical points“ (Engels 1886a: 351). As other examples for nodal lines Engels mentions e.g. a certain current strength that is required to cause the platinum wire of an electric incandescent lamp to glow, the temperature of incandescence and fusion of metals, the freezing and boiling points of liquids, the critical point at which a gas can be liquefied by pressure and cooling (Engels 1886a: 351). The transition from quantity to quality that occurs e.g. in the homologous series of carbon compounds when certain atoms are added can also be termed the emergence of a qualitatively different body.

Other examples that Engels mentioned for the transition from quantity to quality and that could equally be described as the emergence of new qualities in a critical situation after a threshold of a certain control parameter has been crossed, include:

- change of form of motion and energy: “All qualitative differences in nature rest on differences of chemical composition or on different quantities or forms of motion (energy) or, as is almost always the case, on both. Hence it is impossible to alter the quality of a body without addition or subtraction of matter or motion, i.e. without quantitative alteration of the body concerned. [...] Change of form of motion is always a process that takes place between at least two bodies, of which one loses a definite quantity of motion of one quality (e.g. heat), while the other gains a corresponding quantity of motion of another quality (mechanical motion, electricity, chemical decomposition). Here, therefore, quantity and quality mutually correspond to each other“ (Engels 1886a: 349)
- Engels refers to Hegel´s example of the states of aggregation of water (Engels 1886a: 351): “Thus the temperature of water is, in the first place, a point of no consequence in respect of its liquidity: still with the increase of diminution of the temperature of the liquid water, there comes a point where this state of cohesion suffers a qualitative change, and the water is converted into steam or ice“ (Hegel 1874: §108). As other examples Hegel mentions the reaching of a point where a single additional grain makes a heap of wheat; or where the bald-tail is produced, if we continue plucking out single hairs.

For Engels “the negation of the negation is an extremely general […] law of development of nature, history, and thought; a law which, as we have seen, holds good in the animal and plant kingdoms, in geology, in mathematics, in history and in philosophy“ (Engels 1878: 131).
As an example from nature he mentions the development process of a grain of barley: “Billions of such grains of barley are milled, boiled and brewed and then

consumed. But if such a grain of barley meets with conditions which are normal for it, if it falls on suitable soil, then under the influence of heat and moisture it undergoes a specific change, it germinates; the grain as such ceases to exist, it is negated, and in its place appears the plant which has arisen from it, the negation of the grain. But what is the normal life-process of this plant? It grows, flowers, is fertilised and finally once more produces grains of barley, and as soon as these have ripened the stalk dies, is in its turn negated. As a result of this negation of the negation we have once again the original grain of barley, but not as a single unit, but ten-, twenty- or thirtyfold" (Engels 1878: 126). As similar examples he mentions the development process of insects, geology as a series of negated negations, a series of successive chatterings of old and deposits of new rock formations, differential and integral calculus, the development of philosophy and society. These development processes can also be described in the terms of physical self-organisation: the control parameters that influence the development of the grain are time and natural conditions such as heat and moisture. During this development new seeds will show up. At a specific point of time, a critical point is reached and the grain ceases to exist. But at the same time new grains emerge.

Dialectical processes and negation of the negation not just only mean the emergence of other, new qualities, dialectic development also includes development process that results in *higher* qualities and other structural levels. Dialectical development is not just change or self-transformation and self-reproduction, it is also the emergence of higher levels of organisation (Hörz 1976: 311ff). Hence dialectical thinking assumes an immanent hierarchy in nature and evolutionary leaps.

This was also pointed out by Engels: "The transition from one form of motion to another always remains a leap, a decisive change. This is true of the transition from the mechanics of celestial bodies to that of smaller masses on a particular celestial body; it is equally true of the transition from the mechanics of masses to the mechanics of molecules – including the forms of motion investigated in physics proper: heat, light, electricity, magnetism. In the same way, the transition from the physics of molecules to the physics of atoms – chemistry – in turn involves a decided leap; and this is even more clearly the case in the transition from ordinary chemical action to the chemism of albumen which we call life. Then within the sphere of life the leaps become ever more infrequent and imperceptible" (Engels 1878: 61).

Self-organisation theory is also dialectical in the respect that it frequently considers self-organisation as emergent evolution. This means that there are different hierarchical organisational levels of self-organisation that differ in complexity and where new qualities of organisation emerge on upper levels. In self-organisation theory e.g. Ervin Laszlo (1987) argues that evolution does not take place continuously, but in sudden, discontinuous leaps. After a phase of stability a system would enter a phase instability, fluctuations intensify and spread out. In this chaotic state, the development of the system is not determined, it is only determined that one of several possible alternatives will be realised. Laszlo says that evolution takes place in such a way that new organisational levels emerge and identifies the successive steps of evolution. Not all scientists who speak about self-organisation include the development of higher qualities into their concepts. Hence dialectical materialism can in this respect be considered as a broader evolutionary concept than self-organisation.

3. Autopoiesis: Cognition as Construction and/or Reflection?

One of the central issues in epistemology today is whether cognition is a construction or a reflection. I first want to make some comments on the materialistic theory of reflection, then I will take a look at the epistemological implications of autopoiesis theory, and will argue that a materialistic interpretation of autopoeisis is possible.

Already Lenin pointed out that reflection is a quality of matter (Lenin 1952: 82) and his description of matter is connected to this notion of reflection: “Matter is a philosophical category denoting the objective reality which is given to mall by his sensations, and which is copied, photographed and reflected by our sensations, while existing independently of them“ (ibid.: 118f). Taken as an isolated statement, this description is problematic because it can invoke the impression that 1. cognition is only a passive process, not also an active one that is the foundation of transformative human practice, 2. that there is a linear, fully determined reflection of outside reality within a material system, i.e. no autonomy and degree of freedom is granted to the category that is considered as the one being determined by a determining instance. This would be a position of naive, mechanistic realism and a dualistic concept because it wouldn´t consider consciousness as a specific organisational form of matter, but would see it as something external to matter (that nonetheless depends on the latter). Such a description would indeed suggest that subjectivity is not material, idealists or spiritualists could agree with it. E.g. Aristotle or Thomas d´Aquin said that God is an extra-mental, immaterial reality. But one can doubt as I will show that this was really Lenin´s intention. Concerning the first point it can be argued that in the works of Marx and Engels there is much emphasis on freedom that can be achieved by human practice in class struggles. Arguably also Lenin put much emphasis on human practice, hence it is unlikely that he only saw cognition and the actions that are based in it as passive processes.

Concerning the second point one must say that one finds quite some unfortunate formulations in the philosophical works of Lenin as well as of Engels that can create the impression that they wanted to put forward a mechanistic theory of knowledge. In Lenin´s "Materialism and Empirio-Criticism" (1952) there are indeed a number of problematic formulations that can create the impression that cognition produces mechanically an identity between objective reality and sensations. The problem is that Lenin describes reflection sometimes as copies, images, and photographs (see pp. 15, 59, 92, 99, 103f, 118f, 224, 255)[10]. Engels provided an important foundation for a materialist theory of knowledge by pointing out that the great basic question of all philosophy is that concerning the relation of thinking and being (1886b: 338). But he also left many questions open and some of his formulations were later interpreted in mechanistic manner. E.g. he pointed out that the overwhelming majority of philosophers give an affirmative answer to the question if there is an identity of thinking and being (339), said that the thoughts in our heads are "images [Abbilder] of real things" (355) and spoke of "mind images in our heads" (ibid.). The problem is that both Engels and Lenin didn´t give an exact description of reflection and consciously used drastic formulations and technological metaphors in order to stress the difference between their position and idealism and empiricism.

But one can also find passages in Lenin´s works where he points out that his theory of reflection is not based on the naïve realistic assumption of identical reproduction of the outside world in thoughts (which by the way would mean that all human beings were independently from the social circumstances highly prone to manipulation and could be characterised by an almost full degree of homogeneous thoughts). So the question arises what Lenin exactly means when he speaks of mental reflections, pictures or images of things (Lenin 1952: 30f). The following quotations show that the essence of Lenin´s theory of reflection is that objective reality exists outside and independent of human beings and that reflection means only that material reality causes sensations. Material reality is objective in the sense that it existed prior to humans and society, that it is endlessly changing and produces different organisational levels of matter. The human being and its consciousness form one of these levels that is based on interaction and exchange of matter between external world and the body (Lenin 1952: 32f). The materialistic

[10] E.g.: "Materialism is the recognition of "objects in themselves," or outside the mind; ideas and sensations are copies or images of those objects" (15). "Our sensation, our consciousness is only *an image* of the external world, and it is obvious that an image cannot exist without the thing imaged, and that the latter exists independently of that which images it" (59).

views “do not consist in deriving sensation from the movement of matter or in reducing sensation to the movement of matter, but in recognising sensation as one of the properties of matter in motion” (36). “1) the physical world exists *independently* of the mind of man and existed long *prior to* man, *prior to* any “human experience"; 2) the psychical, the mind, etc., is the highest product of matter *(i.e.,* the physical), it is a function of that particularly complex fragment of matter called the human brain” (217). “This is materialism: matter acting upon our sense-organs produces sensation. Sensation depends on the brain, nerves, retina, etc., *i.e., on matter organised in a definite way.* The existence of matter does not depend on sensation. Matter is primary. Sensation, thought, consciousness are the supreme product of matter organised in a particular way” (44). “Matter is primary, and thought, consciousness, sensation are products of a very high development. Such is the materialist theory of knowledge, to which natural science instinctively subscribes” (64).

Lenin wants to stress the primacy of matter, material reality would *evoke* sensations and thoughts in our brains, but not determine the exact content of these thoughts. The following quotation shows that when Lenin speaks of reflection as the production of images of reality he means nothing more than “the existence of things outside our mind, which, by acting on our sense-organs evoke sensations” (102, similarly p. 154): “Sensation is the result of the action of a thing-in-itself, existing objectively outside us, upon our sense-organ – such is Feuerbach´s theory. Sensation is a subjective image of the objective world, of the world *an und für sich*” (108).

Lenin indeed explicitly mentions that there is no absolute identity between thoughts and material reality and that they are to a certain extent different: He says that the “objective connection of the phenomena of nature” can be reflected “only approximately” (Lenin 1952: 145) and that “reflection […] is, of course, approximate” (54). “The objects of our ideas are distinct from our ideas, the thing-in-itself is distinct from the thing-for-us, for the latter is only a part, or only one aspect, of the former, just as man himself is only a fragment of the nature reflected in his ideas” (107). ““Social being” and “social consciousness” are not identical, just as being in general and consciousness in general are not identical. From the fact that in their intercourse men act as conscious beings, it *does not follow* that social consciousness is identical with social being. […] Social consciousness *reflects* social being—that is Marx´s teaching. A reflection may be an approximately true copy of the reflected, but to speak of identity is absurd” (313f).

Also Engels pointed out that reflection should be understood not as the mechanical production of an identity between thoughts and outside reality. He said that there are "necessary limitation of all acquired knowledge, of the fact that it is conditioned by the circumstances in which it was acquired. […] Everything which sets men in motion must go through their minds; but what form it will take in the mind will depend very much upon the circumstances" (Engels 1886b: 356, 360f). We hence should understand reflection only as reactions evoked by material reality in the brain: "The influences of the external world upon man express themselves in his brain, are reflected therein as feelings, impulses, volitions" (Engels 1886b: 345).

So the materialist theory of knowledge as founded by Engels and Lenin indeed is no mechanistic theory, but stresses that the human being and consciousness form an organisational level of matter and that thinking is only possible as a material, practical activity of the human being where there are material input and output flows from and to the natural and social environment that are taken up resp. transmitted by the sense-organs and cause sensations, emotions and experiences in the brain. Harsh philosophical conflicts provoked harsh and misleading formulations by Engels and Lenin. Engels pointed out that the following questions are central for a theory of knowledge: "In what relation do our thoughts about the world surrounding us stand to this world itself? Is our thinking capable of the cognition of the real world? Are we able in our ideas and notions of the real world to produce a correct reflection of reality?" (Engels 1886b: 339). The answer clearly is: Yes, the human being can recognise the world and makes (scientific and practical) efforts for approximating truth. But there is no *automatic* correct reflection of reality, the content of our thoughts depends on many internal and external influences, there is always a certain degree of chance and freedom in thinking that is enabled and constrained to certain extents by the objective material conditions of society. The natural and social environment permanently *evokes* human thoughts, human knowledge itself is not absolute, but depends on the complex interactions of circumstances and hence has limitations and a certain degree of indeterminacy. Thoughts are complexly evoked by the reality of nature and society in a non-linear process, they *resemble* depending on the degree of human progress of society to a certain degree objective reality, but are not identical with the outside environment.

However, it is not true as Lenin (1952) indicated in some passages that there is a linear progress in human knowledge. He said that "incomplete, inexact knowledge becomes more complete and more exact" (92) and that "reflections become more and more faithful" (300). Scientific progress would allow an increasing approximation to objective truth. "From the standpoint of modern materialism i.e., Marxism, the *limits* of approximation of our knowledge to objective, absolute truth are historically conditional, but the existence of such truth is *unconditional,* and the fact that we are approaching nearer to it is also unconditional. The contours of the picture are historically conditional, but the fact that this picture depicts an objectively existing model is unconditional. When and under what circumstances we reached, in our knowledge of the essential nature of things, the discovery of alizarin in coal tar or the discovery of electrons in the atom is historically conditional; but that every such discovery is an advance of "absolutely objective knowledge" is unconditional" (125). Such arguments are clearly an expression of the technological and scientific optimism characteristic for the beginning of the 20th century. Today we live in a phase of capitalism that can be characterised as a high-risk society: technology has a very ambivalent character, it causes at the same time great possibilities and great risks (cf. Fuchs/Hofkirchner 2003 and Hofkirchner/Fuchs 2003). Computerisation and scientific advancements have resulted in a paradox situation where the large development of the productive forces has produced objective material conditions that would enable an immediate transition towards a free society without hard work and exploitation, but at the same time these forces act as destructive forces that tremendously contribute to the enlargement of control, destruction, and heteronomy (Fuchs 2002h, d). We face a condition where both a free society and the destruction of humankind are possibilities, the outcome depends on human practice in class struggle. This paradox situation also means that there is no automatic approximation towards truth and absolute knowledge, indeed the high-risk character of modern society results in permanent advancements of scientific and practical knowledge, but this knowledge massively produces non-knowledge and risks that must be mastered. We today have increased possibilities for approximating absolute truth and societal wisdom, but also increased possibilities for going many steps backwards instead of forward or even annihilating all possibilities for human progress.

Mechanistic determinism argues that causes and effects can be mapped linearly: each cause has one and only one effect, similar causes have similar effects, different causes have different effects; one assumes that small changes of causes necessarily have small effects and large changes of causes necessarily have large effects. Meanwhile the sciences of complexity have shown that similar causes can have different effects and different causes similar effects; small changes of causes can have large effects whereas large changes can also only result in small effects (but nonetheless it can also be the case that small causes have small effects and large causes large effects). When thinking the relationship of a system and its environment dialectically and in terms of the modern sciences of complexity, the notion of reflection shouldn´t be defined in a strictly deterministic manner, there should be room for a dialectic of chance and necessity. This can achieved within a general theory of self-organisation.

By pointing out that one could see reflection as a general quality of matter, Lenin has anticipated interpreting reflection as a general characteristic of self-organising systems. In all self-organising (physical, biological, and social) systems the emergence of order is triggered by fluctuations that cause synergies between the elements of the systems. One can say that influences on the system are reflected within the system, i.e. new order and patterns emerge that can´t be reduced to single elements, but are caused by synergetical interactions. There is a non-linear, complex relationship between causes and effects in self-organising systems: It is objectively conditioned that a fluctuation will at some critical point in the system´s development result in the emergence of new order (necessity). But the exact moment and the exact form of the process of emergence and its resulting new qualities is to a large degree uncertain (chance). Reflection means a complex causal relationship between an entity that causes changes, the system within which these changes take place, and the realisation of these changes within the further development of the system. This broad understanding of reflection has to do with the fact that all self-organising systems are information-generating systems (Fleissner/Hofkirchner 1996, 1997).

Information is a relationship that between specific organisational units of matter. Reflection (Widerspiegelung) means reproduction of and reaction as inner system-changes to influences from the outside of a system. There is a causal relationship between the result of reflection and the reflected. The reflected causes structural changes, but doesn´t mechanically determinate them. There is a certain, relative autonomy of the system, this autonomy can be described as a degree of freedom from perturbations. On the different organisational levels of matter we find different degrees of freedom. This degree increases along with complexity if we go up the hierarchy from physical-chemical to living and finally social systems. The causal relationship between the reflected and the result of reflection is based on a dialectic relationship of freedom and necessity. Information is an objective relationship between the reflected, the result of reflection inside the system´s structure and the realisation of functions of the system within the reflected environment of the system (see Hörz/Röseberg 1981: 273ff). This means that information is a relationship of reflection between a system and its environment, to be more precise between units of organised matter. Information is not a structure given in advance, it is produced within material relationships. "Information is a physical structure and at the same time a structure which dominates the physical forces. […] Information is not a physical substance, it is instead temporarily ´attached´ to it. Information must be understood as a specific effect and as a relationship" (Fuchs-Kittowski 1997: 559f).

When two systems interact, they enter an objective relationship, i.e. a (mutual) causal relationship is established (Fuchs 2003e, f). This is a relationship of reflection that is based on cognition, communication, and co-operation: A portion of subjective, systemic information ("*cognition*") is communicated from system A to system B (and vice versa, "*communication*"). This causes structural changes in the other system. If there is an information relationship between the two systems, it is determined that there will be causal interactions and structural effects, i.e. reflection. The structure of the systems (structural, subjective information) changes, but we don´t know to which extent this will actually be the case, which new subjective information will emerge, which information (structures) will be changed etc. There are degrees of autonomy and freedom (=chance). If structural changes in system B take place and are initiated by system A, this means an objectification of subjective information of A in B from the point of view of A. From the point of view of B it means subjectification of objective information from the environment. In a communication process, this also takes place the other way round. By communication it can not only be the case that an objectification of information in some of the involved systems takes place, it can also be the case that due to the synergies between the systems new qualities (information) emerge in their shared environment (*"co-operation"*). Structural, subjective information of the involved systems is co-ordinated, synergies arise and hence something new is produced commonly in a self-organisation process. The new structure or system that arises is an objectification of subjective information of the involved systems. Information in self-organising systems has cognitive (subjective), communicative (new subjective information (=structures) emerges in systems due to interaction) and co-operative aspects (interaction results in synergies that cause the emergence of new, objectified information in the shared environment of the involved systems) (Fuchs 2003 e,f).

Biology has long struggled for finding a consistent definition of life. Such definitions normally include a list of properties such as movement, metabolism, replication, sensation, reaction to stimuli, growth, ageing, disease, death, reproduction, regulation, inheritance. The problem is that always examples can be found that don´t seem to fit the property lists. Humberto Maturana and Francisco Varela (1992) have tried to find a consistent definition of life, they say that living systems are biologically self-organising ones, i.e. the permanently produce themselves. They call such self-producing systems autopoietic (autos=self, poiein=to make something).

Autopoietic systems or biological self-organisation can be characterised by the following items:

1. They permanently produce their parts and their unity themselves

2. An autopoietic organisation is characterised by relations between its parts
3. These relations result in a dynamic network of interactions
4. Autopoietic systems are operationally closed: the effects of the network of interactions don´t go beyond the network itself
5. The autopoietic unit forms its own border, it delimits its structure from its environment. In a cell the membrane is such a border.
6. The production of the system´s components enables the forming of a border, a border is a precondition for a dynamic that is needed for the self-production of the system (circular causality)
7. Living systems constitute themselves as different from their environment, they are autonomous units.
8. Structural coupling: Perturbations from the environment can influence an autopoietic unit, but it can´t fully determine changes of the system´s structure

The main characteristics of an autopoietic system are self-maintenance, self-production and production of its own border.

In his *Anti-Dühring* and his *Dialectics of Nature*, Friedrich Engels pointed out the problem of defining life and intuitively anticipated the theory of autopoiesis. Of course today we know a whole lot more about life than Engels did, especially since the discovery of the double helix. But what´s important is that Engels anticipated the idea of autopoiesis, he says that life exists in the "constant self-renewal of the chemical constituents" it has (Engels 1878: 75), life is a "self-implementing process" (ibid.: 76), albumen would not only permanently decompose itself, it would also permanently produce itself from its components (Engels 1876a: 558f).

Robert Steigerwald (2000) in his essay on "Materialism and the Contemporary Natural Sciences" also concludes that modern scientific theories like the theory of self-organisation affirm the topicality of dialectical materialism and cause problems for idealistic worldviews. Concerning autopoiesis he has warned against the epistemological consequences of this theory that have frequently resulted in solipsism. People like Matura, Varela, von Foerster, von Glasersfeld, and Luhmann have indeed argued within their epistemological framework of radical constructivism that one should interpret autopoiesis theory in such a way that the brain is an autonomous system, that hence there is no objective reality, only subjectively constructed realities. The whole world would be a construction. Such an epistemology doesn´t comply with the realistic materialist assumption that the material world forms an objective reality that exists independently of our thinking. Radical constructivism is inherently solipsistic and is a form of subjective idealism. It is striking nonsense to assume e.g. as many constructivists do that the flower that I see only exists in my thoughts, but not independently from it.

Autopoeisis as an ontological principle describes the differentia specifica of living (biological) self-organising material systems. It is a mistake to assume that autopoietic systems are closed, fully autonomous systems; permanent material inputs and outputs to our body are a fundamental and necessary condition for autopoiesis. Autopoietic systems are like all self-organising systems open systems that exchange matter with their environment in order to organise themselves, its misleading to argue that they are closed systems (cf. Collier 2003). The brain and the other organs of the human body are self-organising in the sense that based on material inflows and outflows they can maintain and reproduce themselves. When Maturana speaks of structural coupling of an autopoietic system to its environment in the sense that perturbations from the environment can influence an autopoietic unit, but can´t fully determine changes of the system´s structure, this reminds us of Engels´ and Lenin´s theory of knowledge where the material environment of a human body that exists independently of this body evokes sensations and thinking, but doesn´t produce an identity or exact mapping between thinking and being. Understood in such a way, autopoiesis theory indeed confirms dialectical materialism, but one must admit that the dominant interpretation of this theory is an idealistic and solipsistic one.

Cognition means neither autonomous construction, nor mechanistic reflection. The materialistic theory of knowledge has shown that cognitive systems are a specific form of self-organising matter and that the natural and social material environment of a human being is a necessary foundation of cognition. Systems in the environment of a human being permanently cause material data flows that are received by the sense-organs of a particular human being. It is determined that such a reflection takes place permanently, it is not exactly determined which interpretations and actions this reflection will have, only that it will cause changes of the cognitive structural patterns. The external material data is perceived, interpreted and incorporated in an autopoietic process. Cognition is not a passive process, the individual takes actively part in its environment and together with others practically changes this environment. The material flows that result in social interaction and in interaction with the natural world result in an active construction of thinking by the individual. Construction here means that the formation of cognition is influenced by an individual´s active participation in its environment and its practical appropriation of nature. Cognition is neither fully determined nor fully undetermined, the social and natural life world condition a field a possiblilties of cognitive patterns in a certain situation. Which possibility is selected in a certain situation depends on the individual´s history of experiences, its learned patterns of thinking and action, its habitus, its class situation and the complex interplay of outside factors and the individual.

Cognition is both construction and reflection in the sense that the individual actively participates in those conditions that it reflects. Hence in my view a concise materialist epistemology should be a position of constructive reflection (konstruktive Widerspiegelung). Information has subjective as well as objective aspects. It is on the one hand a property of cognitive systems, a difference that makes a difference, and as such it is selected in the communicative process which can be considered as Niklas Luhmann (1984) has shown as an emergent synthesis of three selections (selection of information, uttering and understanding). Due to the selectivity of the communication process, information has a certain degree of uncertainty. On the other hand information is also an objective, reflective social relationship: If actors communicate or an actors interacts with the natural environment, information exists as an objective relationship and this relationship involves reflection. Reflection (Widerspiegelung) doesn´t mean the mechanical reproduction of data by a receiver, it only means that in the case of communication there is a reaction of one communication partner to the symbolic actions of the other partner. It is determined that he reacts and in this reactions he makes uses of symbols, otherwise one couldn´t speak of communication or interaction. But it is not determined how he reacts exactly, this is relatively open, but frequently also to a certain extent predictable due to certain regularities of behaviour that can be found in the social world. Such reflective reactions are neither completely determined, nor completely undetermined, their causality can be characterised as relative chance and incomplete determinism. Such objective information relationships occur milliards of times per day relatively stable, hence information as a social relationship is relatively probable. However there are degrees of uncertainty due to different dispositions, norms, values, habitus, cultural contexts, interpretative schemes, tastes, life-styles etc. of the partners in a communicative setting.

Information exists in all social relationships, but it has different effects. We neither photographically and mechanically map knowledge, nor are we autonomous knowledge producers. Due to certain normative dispositions certain reactions and interpretations to a stimulus are more probable than others. But the human being is a being that can change his views during productive discourses , hence social information relationships not only increase the knowledge of a subject, they also result in a (faster or slower) differentiation of definitions. Human interpretation is neither mechanical mapping, nor coincidental construction, but constructive reflection. Reflection involves reaction to external stimuli during the course of communications where different alternative interpretations and behaviours are possible. It depends on the degree of participation and democratisation of society to which extent interpretation and critical reflection are activated.

4. Sociological Implications of Self-Organisation Theory

Robert Steigerwald (2000) has asked important questions about the philosophical and sociological implications of self-organisation theory: “Does this conception of evolution not also imply the impossibility of predicting the future development of social systems, since at such a bifurcation point the system staggers, fluctuates, tries to replace the old order by a new one, but with no certainty about what will be chosen? Does this not disprove the materialist historical conception that socialism is the system that follows capitalism?”. Social self-organisation happens to be one of my main areas of research, hence I want to give some comments on the sociological implications of self-organisation, but for more details I have to refer the reader to a number of other works (Fuchs 2001; 2002a-c, f-g; 2003a-f, Fuchs/Hofkirchner 2002, Fuchs/Hofkirchner/Klauninger 2001, Fuchs/Schlemm 2002, Fuchs/Stockinger 2002).

Nature is the foundation of society, there is a dialectical mutual coupling between nature and society. It is a false inference to directly transfer principles of physical and biological self-organisation to the societal realm. Hence one must on the one hand philosophically point out general principles of self-organisation that apply to all systems and on the other hand provide for each system type also the differentia specifica of its self-organisation. Human systems differ in a number of respects from other systems, the human being is as Marx has shown the central aspect of societal change (Fuchs 2002b, Fuchs/Schlemm 2002).

Marx pointed out that man like animals lives from inorganic nature, he must remain in a continuing physical dialogue with nature in order to survive. Animals produce only when immediate physical need compels them to do so, the human being actively and consciously identifies and tries to reach goals by producing means with which he appropriates and changes nature. The breakage of immediacy that constitutes goal-oriented, conscious production distinguishes the human being from animals. In the production of his life which includes the metabolism between society and nature and societal reciprocity, man as the universal, objective species-being produces an objective world (gegenständliche Welt) and reproduces nature and his species according to his purposes (Marx 1844a).

The individual is a societal, self-conscious, creative, reflective, cultural, symbols- and language-using, active natural, labouring, producing, objective, corporeal, living, real, sensuous, anticipating, visionary, imaginative, expecting, designing, co-operative, wishful, hopeful being that makes its own history and can strive towards freedom and autonomy (cf. Fuchs 2002b, Fuchs/Schlemm 2002). The human beings has the ability to consciously create together with others new realities and environments. Social self-organisation in a broad synchronous sense e means permanent reproduction of a social system in a process that permanently connects social structures and actors (cf. Fuchs 2002b, 2003a, b). Social structures enable and constrain actions, they are medium and outcome of social actions. This reflexive process is termed re-creation and describes the synchronous process of social self-organisation. Social systems are re-creative systems. The overall self-reproduction of society is not a smooth, permanently stabile process, it is in constant flux and from time to time enters phases of crisis. Hence social self-organisation can in a second, diachronic sense also be understood as being based on the principle of order through fluctuation (cf. Fuchs 2002c, 2003c). Crises are periods of instabilities where the further development of the overall system is not determined. In modern, capitalist society, periods of crisis are caused by developing structural antagonisms. Concerning the evolution of a specific mode of capitalistic development, we find a dialectic of chance and necessity: It is determined that the development of the mode will sooner or later result in a large societal crisis, but it is not fully determined which antagonisms will cause the crisis, when it will take place, and how the result of the crisis will look like.

Is our behaviour determined by social structures? Or can we freely decide how to change these structures? Or can both views be integrated dialectically? Possibly, in phases of instability, social chaos and crisis, social actions are very important and influence the further development greatly. In such situations, small causes can have great effects. It is rather determined that a system like capitalism enters crisis and phases of instability periodically. But the outcome, the concrete course and point of time is left to chance, i.e. it is determined by human agency. The global crisis we are witnessing today is due to the culmination of the antagonisms of capitalism which are all based on the fact that certain groups are included into the conditions of wealth, participation and decision-making whereas others are excluded from it. The material reality of society, i.e. the social forces and relationships, conditions a field of possible future developments, i.e. not everything is possible at any time. Which possibility will be realised in a situation of crisis and high fluctuations is not predetermined, it depends on human practice and the outcome of class struggles. Fundamental social change for the better is neither a necessity nor impossible, the theory of self-organisation shows us that the decisive fact is that it is a possibility and that active human practice is the decisive factor of change. The probability of realising this possibility is not determined, it depends on our responsibility.

Marx was misunderstood by many and interpreted in such a way that he put forward a linear, deterministic stage model of societal development. But indeed there was so much emphasis on practice in Marx´s works. The active human being is the greatest productive force, future developments are conditioned by objective material relationships and forces, but determined by class struggle. The question whether or not capitalism will be followed by socialism can be answered by saying that the capitalistic development of the productive has conditioned the material possibility for a higher type of society, but there is no automatic realisation of this possibility. 100 years from now society could either no longer exist at all due to the continued development of destructive forces, we could still be living in a capitalist society that probably would be a highly militarised, unjust and repressive type of regime or we could indeed be living in a fully democratic and participatory society. These are possibilities that have been conditioned by the development of capitalism that has resulted in today´s large societal crisis. The theory of self-organisation shows us that there is hope for positive change, but this hope must be active, transformative hope.

5. Conclusion: Science, Materialism and Religion

As Engels implicitly pointed out, the substance of the world is its process-character, the permanent dialectical movement of matter and the productivity of matter that results in self-reproduction and the emergence of new, higher qualities and organisational forms of matter. This corresponds to saying that the substance of the world is the permanent self-organisation of matter. As has been shown, processes of physical self-organisation can be described in dialectical terms. Control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory correspond to the dialectical principle of transition from quantity to quality. What is called emergence of order, production of information or symmetry breaking in self-organisation theory corresponds to Hegel´s notions of sublation (Aufhebung) and negation of the negation. The concept of emergent evolution corresponds to the principle of dialectical development, the dialectics of chance and necessity as well as of attraction and repulsion that have been described by Hegel, Engels and Marx are constitutive for processes of self-organisation. The other way round, the examples Engels gave for the dialectics of nature can also be seen as examples of the self-organisation of matter.

Self-organisation theory shows that Engels´ *Dialectics of Nature* is still very topical and that dialectical materialism contrary to mechanical materialism hasn´t been invalidated, it rather seems to be confirmed that dialectics is the general principle of nature and society. Self-organisation theory lines out Engels´ assumptions that the real unity of the world consists in its materiality, that matter is process-like and in constant flux, that it is a producing entity that is uncreateable and indestructible. That the substance of the world is self-organisation of matter which results in higher organisational forms of matter, thus far the highest organisation form is human society, means that God doesn´t exist, that there is no creatio-ex-nihilo and no first mover that isn´t moved itself. Hence religion and esoteric thinking are mere ideology, false consciousness. Dialectical materialism seems be confirmed by modern science, whereas serious problems arise for idealistic worldviews. "The conceptions of self-organisation, the conceptions that assign a determining role to the activity of inner factors instead of outer, are new scientific affirmations of the old dialectical theses, as well as the conceptions of the general connection of all things and appearances" (Steigerwald 2000). Self-organisation theory is indeed a dialectical materialist-theory, but unfortunately its representatives not all to often realise this and don´t acknowledge the dialectical tradition and heritage of the philosophy of nature in the line of Friedrich Engels and Karl Marx.

The natural sciences that emerged during the last century such as quantum theory, quantum mechanics, first and second order cybernetics, general system theory, non-equiblibrium thermodynamics, synergetics, dissipative systems theory, autopoietic systems theory, catastrophe theory, punctuated equilibrium theory, hypercycle theory, string theory, loop theory etc. deal with the ontology of the material world. Hence there seems to be scientific evidence that nature is a self-organising totality and is its own cause. This seems to confirm the materialist notion that matter is uncreateable and indestructible.

20th century science seems to indicate that the assumption that dialectical development is a universal law of nature and that dialectical materialism is right, but frequently human consciousness lags behind the progress of science, technology and society. Linked to the current crisis of the capitalist world system there is a tendency of mysticism and irrationalism spreading in society. This tendency also affects the scientific community.

It is quite common today in idealistic thinking to interpret the big bang as the creation of the world by God where nothing turns into something. But if before the big bang there was nothing except God, what is the foundation of God? There has never been scientific evidence that God could really exist as an eternal substance outside of material existence and that he is his own reason, whereas modern science has produced evidence that matter is causa sui, organises itself and hasn´t been created by an external first mover out of nothing. It is not reasonable to assume that the world has been created out of nothing by God and that God really exists. In such arguments a causal principle is applied to matter, but the same causal principle is declared as not holding for God. There are no rational reasons why this should be the case. Talking about God and the origin of the world means talking about universality, it´s unreasonable to apply a form of universal causality to one universal phenomenon, but to simply ignore it for another one.

Accepting the big bang theory normally means to accept that matter, space, time haven´t existed prior to this event and that they have been created out of nothing. This assumption has been welcomed by idealists and most world religions. Stephen Hawking has reported that the pope told him and other scientists that it is ok to study the evolution of the world after the big bang, but that they shouldn´t research what and if something existed prior to it. Hubble discovered that galaxies are moving away from us, Friedmann and Lemaitre inferred from this that the universe is not only expanding, but must have once been a compressed nucleus ("cosmic egg"). One of the latest version of big bang theory is the inflation theory by Alan Guth who says that the universe at first was a small nucleus and right after the big bang expanded at unimaginable speed, doubling in size every 10 to 35 seconds. Big bang theory certainly poses questions that it can´t answer easily: How can one pack the infinite size of the universe into a finite small point? What existed before the big bang? How can there be a material explosion without matter existing prior to it? "From the standpoint of dialectical materialism, it is arrant nonsense to talk about the ´beginning of time´, or the ´creation of matter´. Time, space, and motion are the mode of existence of matter, which can neither be created nor destroyed. The universe has existed for all time, as constantly changing, moving, evolving matter and (which is the same thing) energy" (Woods/Grant 2002: 193). The big bang theory is indeed a "modern Creation myth" that allows mysticism as well as religious and idealistic thinking to permeate science. The aim of science is the formulation of explanations for that which we do not yet know, explanations which are derived from material reality themselves. Big bang theory puts limits to science, introduces questions that shouldn´t be asked and explained immanently. It is so attracting for mystical thinkers because it allows them to give answers that refer to an external outside of material reality. "Today Big Bang theorists see a universe much like that envisioned by the medieval scholars – a finite cosmos created ex nihilo, from nothing, whose perfection is in the past, which is degenerating to a final end. The perfect principles used to form this universe can be known only by pure reason, guided by authority, independent of observation. Such a cosmic myth arises in periods of social crisis or retreat, and reinforces the separation of thought and action, ruler and ruled. It breeds a fatalistic pessimism that paralyzes society" (Lerner 1981).

That the universe is expanding doesn´t necessarily mean that its whole has been created by a big bang that is singular in character and stands at the beginning of the history of the universe. In fact there are alternative cosmological theories and hypotheses. It could be the case that the explosion took place, but only as an explosion in a small part of the universe due to the combination of matter and antimatter (Hannes Alfvén). Alfvén (1981) suggested that the galaxy contains a large-scale magnetic field and that the cosmic rays move in spiral orbits within the galaxy, owing to the forces exerted by the magnetic field. He said that there could be a magnetic field pervading the entire galaxy if plasma was spread throughout the galaxy. He assumed that due to the fact that the universe is overwhelmingly made up of plasma, plasma phenomena shape the evolution of the universe. This plasma could carry the electrical currents that would then create the galactic magnetic field. Alfvén considered the big bang theory as a myth devised to justify creation. He assumed and tried to show that plasma phenomena (large currents and magnetic fields) shape the evolution of the universe. He pointed out that in his view an explosion in one part of the universe caused by particles that were trapped in magnetic fields resulted in a huge expansion of plasma.

It could also be the case that there can be expansion of certain parts and contraction of other parts of the universe at the same time.

Paul J. Steinhardt and Neil Turok suggest that the evolution of the universe takes place in cycles of expansion and compression and that hence it hasn´t been created and won´t be destroyed, but exists eternally. “The cyclic model is a complete model of cosmic history, whereas inflation is only a theory of cosmic history following an assumed initial creation event. Hence, the cyclic model has more explanatory and predictive power“ (Steinhardt/Turok 2002). According to this theory ”space and time exist forever, the big bang is not the beginning of time; rather, it is a bridge to a pre-existing contracting era, the Universe undergoes an endless sequence of cycles in which it contracts in a big crunch and re-emerges in an expanding big bang, with trillions of years of evolution in between“ (Steinhardt 2002). It addresses many questions that the big bang and inflationary model don´t answer: “What occurred at the initial singularity? What is the ultimate fate of the Universe? What is the role of dark energy and the recently observed cosmic acceleration? Does time, and the arrow of time, exist before the big bang? or after the big crunch?“ (Steinhardt 2002).

Another alternative explanation is cosmic natural selection and the self-organisation of the cosmos: Lee Smolin assumes that the evolution of the cosmos is based on mechanisms that are analogous to the self-organisation of complex systems. The basic idea is that natural selection works at the cosmic level and produces new universes. Universes would originate from black holes. When stars die they sometimes form black holes. Smolin assumes that inside a black hole it´s possible for a small region to, as it were, sprout into a new universe and that the laws of nature of a new universe are related to the laws that applied to the old universe from which the new one stems from. Space-time, Smolin assumes, doesn´t end in black holes, it rather expands to new regions. According to him, universes whose laws permit the formation of black holes will tend to leave more "progeny" than those with different laws, and hence there will be an increasing chance that any given universe will contain black holes. We thus get a process of natural selection, whereby universes that favour the production of black holes will tend to outnumber other universes. This means that a new universe is produced by a universe or a network of universes that has a high production rate of black holes.

Smolin opposes the creation myth and considers an infinite existence of time, space and matter. "If the quantum theory of cosmology requires a non-constructible procedure to define its formal setting, it is something that could only be of use to a mythical creature of infinite capability. One of the things we would like to demand of a quantum theory of cosmology is that it not make any reference to anything at all that might be posited or imagined to exist outside the closed system which is the universe itself" (Kauffman/Smolin 1997). "There never was a God, no pilot who made the world by imposing order on chaos and who remains outside, watching and proscribing. ... The world will always be here, and it will always be different, more varied, more interesting, more alive, but still always the world in all its complexity and incompleteness. There is nothing behind it, no absolute or platonic world to transcend to. All there is of Nature is what is around us. All there is of Being is relations among real, sensible things. All we have of natural law is a world that has made itself" (Smolin 2002: 357f).

The weak anthropic principle (Robert H. Dicke) suggests that due to the fact that there are observers in the universe, the universe must have qualities that allow the existence of these observers. In its strong version (Brandon Carter) the principle suggests that the universe must be built in such a way that it necessarily results in the emergence of observers. This suggests finality. The anthropic principle is based on the assumption that if the parameters of the universe were only changed a little bit, life wouldn´t be possible. Hence it is assumed that human existence is not based on chance, but that some type of necessity, mechanism of "finetuning" or teleology must be built into the universe. Such assumptions allow mystical and idealistic interpretations. If the universe inevitably produces the human being, then the inferences that there is a creator of the universe and that spirit is the highest form of existence (because spirit is assumed to be the absolute goal of the universe) is obvious.

"For example, it appears that electromagnetism, gravity, and the two main forces which control the atomic nucleus, had all of them to have strengths which fell inside very narrow limits if there were to be any stars of the long-living, steadily burning sort: the sort which encourage life to evolve. Again, life´s complex chemistry appears possible only thanks to very precise adjustment of the masses of the neutron, the proton and the electron". (John Leslie, Cosmology and Philosophy, Stanford Encyclopedia of Philosophy)

Margaret Wertheim, host of the PBS TV programme ´Faith and Reason´ argues: "The strong anthropic principle suggests that the laws of the universe are fine-tuned and have been designed to enable beings like us to arrive. In some sense we become the purpose, the end-point, of the universe. To me, that´s a re-importation of natural theology into science, the view that God designed the universe specifically to get man" (*God, Physics, and Turtle Soup*, In: Science & Spirit, July/August 2002)

Paul Davies: "A clear inspection shows that the Earth is endowed with still more amazing ´conveniences´. Without the layer of ozone above the atmosphere, deadly ultraviolet radiation from the sun would destroy us, and in the absence of a magnetic field, cosmic subatomic particles would deluge the Earth´s surface. Considering that the Universe is full of violence and cataclysms, our own little corner of the cosmos enjoys a benign tranquility. To those who believe that God made the world for mankind, it must seem that all these conditions are in no way a random or haphazard arrangement of circumstances, but reflect a carefully prepared environment in which humans can live comfortably, a pre-ordained ecosystem into which life slots naturally and inevitably – a tailor-made world" (Davies 1980: 143). Davies says that there must be some great "cosmic plan". Stephen Hawking says that if the hot big bang model (same temperature everywhere at the beginning of the universe) is right, it "would be very difficult to explain why the Universe should have begun in just this way, except as the act of a God who intended to create beings like us" (Hawking 1988: 127).

The anthropic principle puts forward the Creationist myth, it doesn´t consider cosmos, matter, space and time as infinite, but wants to limit the questions that science is allowed to ask. Hence explanations external to matter and along with it mysticism and esotericism enter. Alternative explanations seem to be much more reasonable than referring to the existence of God:

- It could indeed be accident
- It could be the case that the seeming arbitrariness of these values is an illusion and they are really necessitated by the deepest laws of physics, but attempts to find such laws have so far been unsuccessful.
- Maybe a universe is only possible with such parameters

- Maybe what we consider universe is only part of a much larger universe or a multiverse or a sequence of universes and hence life is no accident, but can be explained by statistic probability
- Lee Smolin assumes that cosmos evolves in a series of universes and that the natural laws of a new universe are a sublation of the natural laws of the universe where it stems from. Comparing a new universe with the one that generated it will show a slight difference in parameter values. If this is the case, the conditions that allow the existence of life have been generated by the self-organisation process of the cosmos. In cosmic natural selection, universes that produce many black holes are more probable. Any universe chosen at random will tend to be one that generates many black holes. Such universes are necessarily rather complex, and so are also good for life. A universe where black holes are abundant must have stars (to turn into black holes) and carbon (to help make stars). This means that any universe with different values of the fundamental constants has fewer black holes and is less likely to exist and survive. "Because the universe is itself a non-equilibrium system, it produces by its own self-organisation processes again and again the conditions that favour the evolution of life" (Smolin 2002: 191f). "I believe that the transition science is now undergoing is part of a necessary process of liberation from the influences of [an] essentially religious view of the world. What ties together general relativity, quantum theory, natural selection, and the new sciences of complex and self-organized systems is that in different ways they describe a world that is whole unto itself, without any need of an external intelligence to serve as its inventor, organizer, or external observer. These are all steps towards a more rational and more complete comprehension of the world based more on what we know and less on myths that have been passed down to us from past generations" (Smolin 2002: 232). Smolin stresses that the universe as we observe it is the result of a steady self-organisation and selection process that includes an increasing fine tuning over a long time.

Besides these alternative arguments it should be stressed that the proponents of the anthropic principle proceed from the false assumption of the finite character of matter, time and space whereas dialectical materialism conceives the cosmos in terms of the eternal, irreversible movement of matter in space-time. The assumption of a (single) universe finite in duration is essentially idealistic.

Philosophy deals with explanations of how single aspects of the world and single sciences are connected. It is the science of universality. Philosophy is the thinking study of material reality and the things that comprise reality. Philosophy works out notions and categories in order to describe and explain the total world process on a general level. Various idealistic, religious and esoteric theories explain the world as being created by God as an external first mover who is not moved himself. This violates fundamental philosophical theorems such as Occam´s Razor: if the material world can be explained as its own reason as can be done by philosophically generalising theories of self-organisation, referring to an external creator is an unnecessary over-specification and multiplication. The theorem of foundation holds that everything that is or can be has some foundation/ground. By starting to tell the history of the cosmos from physics, matter can be conceived as its own reason and as the self-referential foundation of the world. Philosophy actually must explain the development of the universe and must start from physics as the fundamental natural science, idealistic conceptions that stresses spirit will fail to find a sufficient ground of the universe (Zimmermann 1999)[11]. If Spirit and God are conceived as eternal entities that are their own reason, irrational categories are simply defined tautologically and without reference to the really existing, material world that can be rationally explained by the natural and social sciences. Idealism can´t provide a reasonable foundation of the world.

The existence of God has never been proved scientifically, but there is all reason to assume that matter is organising itself and that this is a universal phenomenon. The theory of the hypercycle by Manfred Eigen provides an explanation of the origin of life and the human being that is in no need for an argument that assumes divine creation because the emergence of life is explained as a qualitative leap in the self-organisation of matter that results in a new organisation level within an evolutionary hierarchy. Life is the result of a cross-catalysis between auto-creative nucleic acids and proteins. "There is no need for a miracle, for a divine, supernatural act to explain biological development. The only possibility of avoiding this conclusion would be the statement that the laws ruling it have been created together with the world by an extrahuman force. But then reasonable arguments for the possibility and necessity of this extranatural power must be found, and that cannot be established by scientific means" (Steigerwald 2000). The existence of life is due to self-reproducing molecules, there is no scientific evidence for a creation of life and the human being by God.

[11] Law of Ground: "Ground, like the other determinations of reflection, has been expressed in the form of a law: everything has its sufficient ground. This means in general nothing else but: what *is*, is not to be regarded as a merely *affirmative immediate* but as something *posited*; we must not stop at immediate determinate being or determinateness as such, but must go back from this into ground, in which reflection-into-self in contrast to mere being is expressed. To add that the ground must be *sufficient* is really quite superfluous for it is self-evident; that for which the ground is not sufficient would not have a ground, but everything is supposed to have a ground" (Hegel 1969: §969).

Idealism is in one of its version based on a dualism of mind and matter, in another one matter is reduced to mind. Taking a look at the history of the division of labour shows that this division resulted in a widening separation between manual and mental labour. The emergence of this separation coincides with the emergence of class-based society. Idealism got a boost from the emergence of classes and heteronomous societies and the other way round it is an ideology that justifies and is helpful in upholding such societies[12].

With the breakdown of Fordist capitalism in the sixties, the capitalist world system entered a permanent crisis and ever since the global groblems have quickly worsened. A new Postfordist mode of capitalist development emerged and individualisation has shown up as a new phenomenon that serves dominating interests and results in the erosion of collective institutions that formerly seemed to give sense to the human being. Such institutions are traditional religions, unions, associations, families etc. Capitalism is now based on a deregularised and flexible institutional setting (flexible regime of accumulation, neo-liberal mode of regulation) and people throughout the world are faced with the dangers of precrariousness and extinction that are due to the development of the internal antagonisms of the capitalist world system. With the breakdown of the Soviet Union, an ideological vacancy showed up and the former Eastern European states have been fully included into the global capitalist dynamics.

In ideology and science, the emptiness and helplessness that is felt by many and that is due to the antagonisms of the capitalist world system has resulted in a search for new transcendental and mystical explanations and salvations. As a result there is a boom of various forms of mysticism, esotericism and spiritualism. People are looking for irrational guidelines, instead of looking for the foundations of problems and developments within the real world. The new irrationalism is a result of the increased complexity of the world that people can´t cope with. These irrational tendencies can also be found within the self-organisation paradigm that has by some been interpreted as holistic spiritualism.

E.g. for the Austrian systems philosopher Erich Jantsch spirit is the guiding force of evolution, spirit´s self-organisation would result in organisational levels. For him, history is history of the spirit and he says that the materialistic argument that humanity can be described by material processes is reductionistic (Jantsch 1979:

[12] "Essentially, philosophical idealism is a product of the extreme division between mental and manual labor which has existed from the dawn of written history down to the present day" (Woods/Grant 2002: 36).

252, 330, 346). He considers the history of nature as the evolution of consciousness and spirit (1979: 411) and suggests that spirit is a god-like principle. God is considered as the evolving spirit of the universe.

Jantsch suggest that there is a hierarchy of natural systems (Jantsch 1975: 72) that stretches from physical to biological, social and finally spiritual systems. Very similar to the world model of Karl Popper (see Eccles/Popper 1977: 38) where world three corresponds to the products of human mind, spirit seems to be some upper guiding principle of evolution for Jantsch. Hence the upper system in his hierarchy is not society – that includes material processes as well as human ideas –, but spirit. This again outlines Jantsch´s idealistic view of the world. Jantsch (1979: 243) says that it is the neural spirit that steers the evolution of the human world.

Jantsch (1975) refers positively to Henri Bergsons´s eschatological and metaphysical concept of élan vital, a life force that (as is assumed) drives evolution toward higher forms of organisation. Jantsch himself says that the formation of life should not be explained by random fluctuations, but by a special, attractive, higher force that drives towards finality and was called entelechy by Hans Driesch and élan vital by Bergson. Self-organisation theory puts forward the idea that life has come into existence by the self-organisation of matter without an external creator (God) or a metaphysical force at work. Although Jantsch is into this theory and tries to apply it to society, he is explaining life in an irrational manner. For Jantsch evolution does not take place randomly or as a dialectic of chance and necessity, he sees some finalistic, teleological principle at work. Jantsch´s view is a monistic idealism, he says that all human systems – organisations, institutions, cultures, and so forth – are alive (Jantsch 1975: 50) and that self-organisation on all evolutionary levels means the unfolding of spirit (Geist). Jantsch´s says that spirit is everywhere dissipative self-organisation takes place, especially in all areas of life (Jantsch 1979: 227). For Jantsch, spirit is also in society, eco-systems, the “gaia”-system or in the insect world.

Similar arguments can be found in the works of Fritjof Capra who considers the total dynamics of self-organisation in the cosmos as cosmic mind and regards self-organisation as a mental process. “In the stratified order of nature, individual human minds are embedded in the larger minds of social and ecological systems, and these are integrated into the planetary mental system - the mind of Gaia-which in turn must participate in some kind of universal or cosmic mind. The conceptual framework of the new systems approach is in no way restricted by associating this cosmic mind with the traditional idea of God. In the words of Jantsch, "God is not the creator, but the mind of the universe." In this view the deity is, of course, neither male or female, nor manifest in any personal form, but represents nothing less than the self-organizing dynamics of the entire cosmos“ (Capra 1982).

In such mystical views, the universe is seen as one large living totality that consists of a network of equal parts. There is no hierarchy in nature in such conceptions and hence also no qualitative differences between systems, they are all considered as an expression of spirit. Based on the Gaia hypothesis, biologistic and eco-fascistic arguments frequently are employed.

In such new mystifications and irrationalifications of science, God is not necessarily considered as an eternal creator, but there is an eternal principle that exists externally to matter. Capra stresses the similarities between his systems view and mystics. Consciousness is regarded as the primary reality and the ground of all being. “In its purest form, consciousness, according to this view, is non-material, formless, and void of all content; it is often described as "pure consciousness", "ultimate reality", "suchness" and the like. This manifestation of pure consciousness is associated with the Divine in many spritual tradions. It is said to be the essence of the universe and to manifest itself in all things; all forms of matter and all living beings are seen as forms of divine consciousness“ (Capra 1982). Capra doesn´t consider material structures as primary reality, all structures of the universe from particles to galaxies and from bacteria to human being are considered as manifestations of the cosmic mind. “But this is almost the mystical view“ (Capra 1982). Capra says that both the ideas of the universal interconnectedness and interdependence of all phenomena and the intrinsically dynamic nature of reality can be found in science and mystical traditions.

Philosophy is not an area of religious belief, religion is not a part of science and philosophy. Values and norms are part of ethics, which comprises one part of philosophy. The other ones are ontology (What is the world and all being like?) and epistemology (How do we perceive the world?). Philosophy is not an area where “anything goes“ in the sense of a radical constructivist or anarchistic epistemology of science as e.g. put forward by Paul Feyerabend. Philosophy instead tries to connect, to generalise and to unify single sciences. It produces interrelationships between single sciences on a more general meta-level. Hence it is based on the natural and social sciences, philosophical categories are related to the single sciences. E.g. categories like reason, love, human being are related to the humanities, categories like nature, space, time, matter are related to physics etc.

Categories like God and spirit that are conceived as the Absolute, as something infinite and unquestionable and as absolute truth are not at all connected to the single sciences. This results in isolated doctrines that can´t be analysed, questioned and examined scientifically. There is e.g. no proof for the claim that man occupies some lower steps in a universal field where God means the Absolute. The realm of religion, mysticism, spiritualism and esotericism is where science ends and pure ideology starts.

Hegel said that “what is reasonable is actual and what is actual is reasonable“. Actuality means materiality, hence putting Hegel from head to toe means that only material reality can be reasonable, and that something that is conceived as existing prior or external to matter is unreasonable. Areas such as religion and esotericism are unscientific and irrational, they proclaim absolute truths that can´t be researched or contested. Irrational arguments avoid objectiveness, exactness, logic, verifiability and falsifiablity. Pseudo-sciences use strategies of immunisation in order to avoid criticism. If pseudo-sciences like creationism, spiritualism, mysticism, parapsychology and astrology were right, this would mean that the modern sciences are all wrong. Hence isolationism is typical for such areas of thinking.

There are no scientific grounds for religion and other irrationalisms. Religions might include some elements that are interesting for science and philosophy, but one has to deal with these topics scientifically, not religiously and in terms of absolute truths. Religion and esoterics are a “universal basis of consolation and justification. Religious suffering is, at one and the same time, the expression of real suffering and a protest against real suffering. Religion is the sigh of the oppressed creature, the heart of a heartless world, and the soul of soulless conditions. It is the opium of the people“ (Marx 1844b: 378).

There is no need to refer to mystic forces for explaining the self-organisation of the universe and society. New properties simply emerge due to the complex interactions of the parts of a system, not because there would be some external holistic force at play. Already the founders of the Philosophy of Emergentism, Conwy Llord Morgan and Samuel Alexander saw emergence as something mystically, and so they introduced spiritual forces (known as "Nisus") as the driving principle. Such forces lack an understanding of the dialectical relationship of quality and quantity and the whole and its parts. The emergence of order doesn´t need to be explained metaphysically because new qualities of the whole are solely constituted by interactions of its parts. The philosophical mistake of over-specification that is grasped by Occam´s razor is made by holistic thinkers such as Jantsch and Capra. This opens the way for irrationalism and esotericism, which belong to the scope of ideology rather than to (critical) science.

References:

Alfvén, Hannes (1981) *Cosmic Plasma.* Dordrecht. Reidel.

Bak, Per (1996) *How Nature Works.* New York. Copernicus/Springer.

Best, Steven/Kellner, Douglas (1997) *The Postmodern Turn.* Guilford Press

Bloch, Ernst (1963) *Tübinger Einleitung in die Philosophie.* Frankfurt/Main. Suhrkamp

Bloch, Ernst (1975) *Experimentum Mundi.* Frankfurt/Main. Suhrkamp

Bloch, Ernst (2000) *Logos der Materie.* Frankfurt/Main. Suhrkamp
Brunk, Gregory G. (2002) *Why Do Societies Collapse? A Theory Based on Self-Organized Criticality.* In: Journal of Theoretical Politics, 14(2). pp. 195-230.

Capra, Fritjof (1982) *The Turning Point.* New York. Simon and Schuster.

Checkland, Peter (1981) *Systems Thinking. Systems Practice.* Chicester. John Wiley

Collier, John (2003) Organisation in Biological Systems. In this book.

Davies, Paul (1980) *Other Worlds* New York. Simon & Schuster.

Ebeling, Werner/Feistel, Rainer (1994) *Chaos und Kosmos - Prinzipien der Evolution*, Heidelberg/Berlin/Oxford. Spektrum.

Eccles, John/Popper, Karl (1977) *Das Ich und sein Gehirn.* München. Piper. 6th Ed.

Eigen, Manfred/Schuster, Peter (1979) *The Hypercycle.* Berlin/Heidelberg/New York. Springer.

Engels, Friedrich (1878) *Herrn Eugen Dührings Umwälzung der Wissenschaft.* In: MEW, Vol. 20. Berlin. Dietz. pp. 1-303

Engels, Friedrich (1886a) *Dialektik der Natur*. In: MEW, Vol. 20. Berlin. Dietz. pp. 305-570.

Engels, Friedrich (1886b) *Ludwig Feuerbach und der Ausgang der klassischen deutschen Philosophie*. In: Marx/Engels (1974) Ausgewählte Schriften in zwei Bänden, Vol. 2. pp. 328-369

Fleissner, Peter/Hofkirchner, Wolfgang (1996) Emergent Information. In: BioSystems 2-3(38)/1996, pp. 243-248

Fleissner, Peter/Hofkirchner, Wolfgang (1997) Actio non est reactio. An Extension of the Concept of Causality Towards Phenomena of Information.

Fuchs, Christian (2001) *Soziale Selbstorganisation im informationsgesellschaftlichen Kapitalismus.* Vienna/Norderstedt. Libri BOD

Fuchs, Christian (2002a) *Concepts of Social Self-Organisation.* INTAS-Project "Human Strategies in Complexity"-Research Report, 69 pages, Vienna University of Technology, Online at: http://www.self-organisation.org

Fuchs, Christian (2002b) *The Role of the Individual in the Social Information Process*. FIS (Foundations of Information Science) E-Conference 2002 Paper. In: FIS 2002 Proceedings. *Entropy*, 5 (1): 34-60. http://www.mdpi.org/entropy/papers/e5010034.pdf

Fuchs, Christian (2002c) *Krise und Kritik in der Informationsgesellschaft. Arbeiten ueber Herbert Marcuse, kapitalistische Entwicklung und Selbstorganisation*, Libri BOD, Vienna/Norderstedt.

Fuchs, Christian (2002d) *On the Topicality of Selected Aspects of Herbert Marcuse´s Works*. In: Fuchs (2002f). Online: http://cartoon.iguw.tuwien.ac.at/christian/marcuse/marcuseENG.html

Fuchs, Christian (2002e) Software Engineering and the Production of Surplus Value. In: *Cultural Logic*. 4(3). http://www.eserver.org/clogic/2002/fuchs.html

Fuchs, Christian (2002f) *Some Implications of Anthony Giddens´ Works for a Theory of Social Self-Organisation*. In: *Emergence*. 4(3): 7-35.

Fuchs, Christian (2002g) *Social Information and Self-Organisation*. In: Trappl, Robert (Ed.) (2002) *Cybernetics and Systems 2002. Proceedings of the 16th European Meeting on Cybernetics and Systems Research*. Vienna. Austrian Society for Cybernetic Studies. pp. 225-230.

Fuchs, Christian (2002h) *Die Bedeutung der Fortschrittsbegriffe von Marcuse und Bloch im informationsgesellschaftlichen Kapitalismus*. In: Utopie Kreativ 141/142, pp. 724-736.

Fuchs, Christian (2003a) *Structuration Theory and Self-Organisation.* INTAS-Project “Human Strategies in Complexity“-Research Paper. In: *Systemic Practice and Action Research*, 16 (2): 133-167.

Fuchs, Christian (2003b) *Some Implications of Pierre Bourdieu´s Works for a Theory of Social Self-Organisation*. INTAS-Project “Human Strategies in Complexity“-Research Paper. In: *European Journal of Social Theory*. 6(4) (forthcoming).

Fuchs, Christian (2003c) *Modern Society - A Complex, Evolutionary, Self-Organising, Antagonistic System*. INTAS Project “Human Strategies in Complexity”-Research Paper. In: Social Science Research Network eLibrary: http://ssrn.com/abstract=385220 (published as The Self-Organisation of Modern Society. In: Studies in Political Economy, Vol. 25 (2003) (forthcoming).

Fuchs, Christian (2003d) *The Self-Organisation of Politics, Power and the Nation State*. In: Social Science Research Network eLibrary: http://ssrn.com/abstract=385222

Fuchs, Christian (2003e) Co-operation in Complex, Self-Organising, Information-Generating Systems. In: Proceedings of the Conference “Agoras of the Global Village”, Crete, July 7th-11th, 2003. International Society for Systems Sciences (ISSS).

Fuchs, Christian (2003f) Co-operation and Self-Organisation. In: Triple C (http://triplec.uti.at), Vol. 1 (2003), No. 1 (forthcoming).

Fuchs, Christian/Hofkirchner, Wolfgang (2002) Information in Social Systems. In: Schmitz, Walter (Ed.) Sign Processes in Complex Systems, Proceedings of the 7th International Congress of the IASS-AIS. Thelem. Dresden 2002, ISBN 3-933592-21-6.

Fuchs, Christian/Hofkirchner, Wolfgang (2003) *Studienbuch Informatik und Gesellschaft*, Libri BOD, Wien/Norderstedt.

Fuchs, Christian/Hofkirchner, Wolfgang/Klauninger, Bert (2001) *The Dialectic of Bottom-Up and Top-Down Emergence in Social Systems*. Talk at the Congress

"Problems of Individual Emergence", Amsterdam, 16.-20.4.2001, in *Proceedings of the Congress "Problems of Individual Emergence"* (forthcoming). In: Social Science Research Network eLibrary: http://ssrn.com/abstract=385185

Fuchs, Christian/Schlemm, Annette (2002). "The Self-Organisation of Society," INTAS Project "Human Strategies in Complexity"-Research Paper. In: *Natur & Ökonomie*. 1(1) (forthcoming). In: Social Science Research Network eLibrary: http://ssrn.com/abstract=385284

Fuchs, Christian/Stockinger, Gottfried (2002). *The Autocreativity of Social Communication Systems and the Re-Creativity of Social Action Systems*. In: Arshinov/Fuchs (2003).

Fuchs-Kittowski, Klaus (1997) *Information neither Matter nor Mind On the Essence and on the Evolutionary Stage Concept of Information*. In: Wolfgang Hofkirchner (Ed.) (1997) *The Quest for a Unified Theory of Information*. In: World Futures, 1997, Vol. 50. pp. 551-570

Haken, Hermann (1978) *Synergetics* Springer

Haken, Hermann (1983) *Advanced Synergetics*. Springer

Haken, Hermann (1987) *Die Selbstorganisation der Information in biologischen Systemen aus der Sicht der Synergetik*. In: Küppers, Bernd-Olaf (Ed.) (1987) *Ordnung aus dem Chaos- Prinzipien der Selbstorganisation und Evolution des Lebens*. München. Piper. pp. 127-156

Hawking, Stephen (1988) *A Brief History of Time.* New York. Bantam.

Hegel, Georg Wilhelm Friedrich (1874) *The Logic of Hegel. translated from the encyclopaedia of the philosophical sciences by William Wallace.* 2nd Edition. London. Oxford University Press

Hegel, Georg Wilhelm Friedrich (1969) *Hegel´s Science of Logic.* London. Allen & Unwin.

Hodgson, Geoffrey (2000) *The Concept of Emergence in Social Science: Its History and Importance*. In: Emergence, Vol. 2 (2000), No. 4. pp. 65-77.

Hofkirchner, Wolfgang (1993) *Zwischen Chaos und Versklavung. Die Entgrenzung der Naturwissenschaften und die Mauern im Kopf*. In: Forum Wissenschaft, No. 37. pp. 7-18.

Hofkirchner, Wolfgang (1998) *Emergence and the Logic of Explanation.* In: Acta Polytechnica Scandinavica, Mathematics, Computing and Management in Engineering Series 91 (1998). pp. 23-30.

Hofkirchner, Wolfgang/Fuchs, Christian (2003) The Architecture of the Information Society. In: Proceedings of the Conference "Agoras of the Global Village", Crete, July 7th-11th, 2003. International Society for Systems Sciences (ISSS).

Hörz, Herbert (1976) *Marxistische Philosophie und Naturwissenschaften.* Berlin. Akademie

Hörz, Herbert/Röseberg, Ulrich (1981) *Materialistische Dialektik in der physikalischen und biologischen Erkenntnis.* Berlin. Akademie

Jantsch, Erich (1975) *Design for Evolution.* New York. George Braziller.

Jantsch, Erich (1979/1992) *Die Selbstorganisation des Universums. Vom Urknall zum menschlichen Geist.* München/Wien. Hanser

Kant, Immanuel (1787) *Critique of Pure Reason.* Translated by Norman Kemp Smith. Houndmills, Basingstoke Hants. Macmillan.

Kauffman, Stuart/Smolin, Lee (1997) *A Possible Solution For The Problem Of Time In Quantum Cosmology. SFI Institute Working Paper No. 97-03-020.*

Laszlo, Ervin (1987) *Evolution. The Grand Synthesis*. Boston. Shambhala.

Lenin, W. I. (1952) *Materialismus und Empiriokritizismus*. Berlin. Dietz

Lerner, Eric J. (1991) *The Big Bang Never Happened.* New York. Times Books.

Luhmann, Niklas (1984) *Soziale Systeme*. Frankfurt/Main. Suhrkamp.

Marquit, Erwin (1980) *Stability and Development in Physical Science.* In: Burger, Alan et al. (Eds.) (1980) Marxism, Science and the Movement of History. Amsterdam. Gruener. pp. 77-104.

Marx, Karl (1844a) *Introduction to A Contribution to the Critique of Hegel´s Philosophy of Right*. In: MEW, Vol. 1. Berlin. Dietz. pp. 378-391.
Marx, Karl (1844b) *Ökonomisch-Philosophische Manuskripte.* In: MEW, Ergänzungsband 1. Berlin. Dietz. pp 465-588.

Maturana, Humberto/Varela, Francisco (1992) *The Tree of Knowledge*. *The Biological Roots of Human Understanding.* Shambhala

Nicolis, Gregoire/Prigogine, Ilya (1989) *Exploring Complexity.* New York. Freeman.

Prigogine, Ilya (1980) *From Being to Becoming*. New York. Freeman.

Prigogine, Ilya/Stengers, Isabelle (1984) *Order out of Chaos.* New York. Bantam.

Schelling, F: *Sämtliche Werke*. Edited by K.F.A. Schelling. Stuttgart. Cotta.

Schrödinger, Erwin (1953) *What is Matter*. Reprinted in: Scientific American, 1991, Special Issue: Science in the 20th Century. http://www.idea-tr.com/metinler/schrodinger_matter/what_is_matter.htm

Schrödinger, Erwin (1980) *The Present Situation in Quantum Mechanics. In: Proceedings of the American Philosophical Society*, 124, pp. 323-38. http://www.emr.hibu.no/lars/eng/cat/Default.htm

Smolin, Lee (2002) *Warumgibt es die Welt? [The Life of the Cosmos]*. München. dtv.

Steigerwald, Robert (2000) *Materialism and the Contemporary Natural Sciences.* In: Nature, Society, and Thought. Vol. 13 (2000), No. 3, pp. 279-323.

Steinhardt, Paul J./Turok, Neil (2001) *A Cyclical Model of the Universe.* http://xxx.lanl.gov/PS_cache/hep-th/pdf/0111/0111030.pdf

Steinhardt, Paul J. (2002) *The Endless Universe. Introduction to the Cyclic Universe.* http://www.actionbioscience.org/newfrontiers/steinhardt.html

Woods, Alan/Grant, Ted (2002) *Reason in Revolt. Dialectical Philosophy and Modern Science. Volume 1.* New York. Algora.

Zeilinger, Doris (2002) *Spinoza, the "very Untranscendental". Ernst Bloch´s Interpretation of Spinoza.* In this Book.

Zimmermann, Rainer (1999) *The Klymene Principle. A Unified Approach to Emergent Consciousness.* Kasseler Philosophische Schriften, Materialien und Preprints, IAG für Philosophische Grundlagenprobleme. UGH Kassel

Emergence and Self-Organisation of Complex Systems. The Role of Energy Flows and Information

Norbert Fenzl

Abstract

How does order emerges from noise? How does higher complexity arise from lower complexity? For what reason does a certain number of open systems start interacting in a coherent way, producing new structures, building up cohesion and new structural boundaries?
To answer these questions we need to precisely line out the concepts we use to describe open systems and the basic driving forces of self organisation. We assume that the basic driving forces of self organisation processes are related to the flow and throughput of *Energy and Matter* and the production of system-specific *Information*. These two processes are intimately linked together: Energy and Material flows are the fundamental carriers of *signs* which are processed by the internal structure of the system to produce system-specific Information.
So far, the present theoretical reflections are focused on the emergence of open systems and on the role of Energy Flows and Information in a self-organizing process.
Based on the assumption that Energy, Mass and Information are intrinsically linked together and are fundamental aspects of the Universe, we discuss how they might be related to each other and how they are able to produce the emergence of new structures and systems.

Introduction

To respond to the basic question of the following paper we consider it necessary to give a more precise definition of the concepts we use to describe the process of emergence and self organisation. On the other hand we need to say that we talk about open systems in a general abstract way, without dealing with specific physical, biological or social systems.

We try to describe a very basic process which assumes different qualities on different levels of complexity. So far, concepts like information, signal, signs, and others are used independently of concepts like meaning or understanding in the sense of human communication.

Basic physical concepts

Mass, Matter and Energy

Historically matter is one of the oldest concepts closely related to the form of physical objects. On the other hand the term energy comes up only in the 19th century as a „counter-concept" to matter and, using the words of C.F.Weizsäcker, as a „substantialisation" of the 17th century´s concept of force (Weizsäcker 1971).

Energy, is often defined as mass in movement. This general concept of energy has two basic and antagonistic aspects: Energy as Heat, playing the role of a universal „random generator" and Energy as Work, as a kind of „order generator", producing organized structures.[1]

At this point we would like to recall the important statement of Tom Stonier (1992): "what mass is to matter, heat is to energy, organisation is to information". In agreement to this, say that matter is *organized mass*, or in more precise terms, *"organized movement of mass*". And, of course, to organize mass the therefore needed energy appears as (system specific useful) work. We remember also that heat and mass are supposed to appear nearly simultaneously (protons emerge approximately 10^{-11} seconds after the Big Bang) with the beginning of the Universe. So we can say that heat, as "unorganized movement of mass", is the "mother" of all other kinds of energy we know. All the other types of energy are ultimately expressed in forms of work, and so far, as ability to organize mass to matter.

Without going into thermodynamical details, for our further understanding we consider that input energy of open systems is basically used in two basic ways: to perform (system specific) work and to overcome structural inertia, the dissipated part of energy we call entropy. Finally in our understanding, the concepts of work and entropy are system specific in the sense that the concept of entropy only makes sense "inside" the system and cannot be exported as entropy, but only as energy.

Open self-organized systems

In the present analysis we concentrate our attention specifically on*, open, autopoietic, self-organized systems*. These systems are composed of three basic dimensions of space-time:

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[1]P.W.Atkins in „The Second Law" (Scientific American Books, 1984) uses heat and work very strictly in this sense. We distinguish (for the present purpose) between system-specific „useful work" and the most general traditional idea of work. But it is clear, that the same energy can be *destructive* for a system and *constructive* for another.

* the microscopic dimension of the individual element,
* the mesoscopic dimension of the structure limited by the structural boundary,
* the macroscopic dimension of the field of interaction or relevant environment, limited by the system boundary.

Element

The concept of the element is related to the smallest unity of the structure, which is still relevant for the mesoscopic characteristics of a system. The elements constitute the microscopic dimension of the system. For example if we talk about some complex organic molecule, the atoms (C, H, or others) can be classified as elements. This is not the case of an organism, such as a plant for example, where the concept of element makes sense only if it designates at least a cell.

Structure

The concept of structure is related to the ”body aspect” of a system. We situate the structural boundary at the mesoscopic level of the system to describe its intermediate position between micro- and macro-dimension of the whole system. Structural boundaries as interfaces between different mediums assume very important roles as mediators between the inner and the outer space of system-structures. The basic characteristic of the structure of a system is its structural inertia, the resistance of organized matter against movement (changes). The amount of *energy* required to overcome structural inertia (entropy) produces heat which is lost by dissipation, and the amount of energy needed to organize (or *re*organize) material structures is what we call *work*. The antagonism between these two fundamental aspects of energy seems to be the basic driving force of self-organisation.

Field of interaction

The concept of the field of interaction (or system-relevant environment) constitutes the macroscopic dimension of a system. As we know, all open systems are submitted to the same cycle: emergence, development, decay and death. During this cycle the structure of open systems suffers characteristic transformations interacting permanently with its relevant environment through the exchange of energy and matter, characterized by energy-input of higher quality (E1) and energy-output of lower quality (E2). The potential difference between these two qualities is exactly what makes self-organisation working.

The input-energy is used by the system to:

a) Weaken or break up the bonds (the cohesion) between the elements of the system dissipating energy (*Entropy*).

b) Reorganize the elements with the aim to (re) stabilize the mesoscopic structure by *realization of Work* (Stonier 1990).

This is the basic process which gives adaptability to the system with respect to environmental changes.

Energetic-material metabolism (EMM)
The complete process of input-transformation (throughput)-output, called energetic-material metabolism (EMM) of the system, imposes specific changes to its inner (microscopic) and outer (macroscopic) space: during their ”life time” open systems transform part of their survival-relevant environment, creating a specific macroscopic dimension of space-time, the field of interaction, which turns out to be a characteristic and inseparable part of (at least) all open and self-organized systems.

The fact, that we include the field of interaction into the concept of system, means that distinguish between the structural - and the system- boundary. So, open systems cannot be reduced to their structural dimensions and what we call *system* is necessarily greater than the physical dimensions of its structure.

On the one hand the process of EMMM *produces* its corresponding interaction field. On the other hand, the same process *obliges* the system to react to all changes of its relevant environment. So far, the necessary structural changes are related to the external changes, which are partly caused by the system itself. Maybe we can recall at this point the analogy between the relationships like: particle/wave, body/mind and mass/field.

A system only can interact with its relevant environment according to the dynamics of its own structural organisation, or, according to the dynamics and needs of its own EMM, which functions according to the structural organisation of the system and needs to adapt the environment to its specific requirements. These so caused changes in the field of interaction we call, in a very general way, signs, without distinction if these signs are intentional or not. Since signs are produced by a specific type of structural organisation, they naturally reflect essential characteristics of the structure which produces them.

Information

What are the concept and the role of Information in the evolution of open, self-organized systems? What is the relationship between Information, Energy, Mass and Information? Before trying to define the concept of Information and analyze its role in the process of emergence, it is necessary to focus briefly on some underlying concepts, like sign, signal, symbol and data, to explain how we use these concepts in our analysis.

Signs
Basically, a sign is something that stands for something else. Also here we can find different approaches. For example, Korzybski defines a sign as a map which means a territory. As an example we can mention the different worldwide used signs to design bathrooms, airports, danger, etc. For C. S. Peirce, "a sign is something that stands for something else to someone in some respect". This definition is more complex and Peirce includes the necessary person. Some authors (especially Korzybski and S. I. Hayakawa in "General Semantics") use the concept of *symbol*, meaning what others call signs.

Generally we can say that people working with linguistics would say that *words* are signs: So, a certain word (lets say car), has a *potential meaning* (what is written in the dictionaries) and a *specific meaning* (for a specific person) when used in a specific context. We would like to use the terminology in the way of: A sign stands for something else "in some respect" and does not represent all of the thing or experience to which it refers. In our context we would use as example a footprint, or all kinds of changes in the environment which can be computed by the system.

Signals
There are mainly two definitions for *signal* which are satisfying the purpose of our present analysis: *detectable quantity of transmitted energy that can be used to carry information* and
time-dependent variation of a characteristic of a physical phenomenon, used to convey information

In electronics the concept is mainly used to describe any *transmitted electrical impulse*. Of course signals also are used in the scope of *human communication*. In this case signals generally design a type of *message* which can consist of one or more letters, words, characters, signal flags, visual displays, or special sounds, with prearranged meaning and which is conveyed or transmitted by visual, acoustical, or electrical means.

But as we stated initially we use the concept in a very general way, considering human communication only a quality of a specific open system, the human society. So far we do not link the concept to some kind of meaning, in the sense of human *understanding*. In our context, changes (differences) of the energy/matter input "mean" something for the system if they cause perceptible changes in it.

Symbols

Even if we consider that the concept of the symbol is directly linked to human communication and cultural phenomena, it is important to mention that often symbol and sign are used in a confusing way. So, we will not extend on its definition, because it only has a limited utility in our context.

But even so, we would use the word in the following sense: a symbol stands for something more than for something "in some respect" and represents more than the thing to which it literally refers. In other words, a symbol is a complex association of different meanings and its interpretation depends largely on the cultural background of the symbol itself.[2]

Data

People working with computer science define generally data as *information that has been translated into a convenient form to store, move or process*. Relative to today´s computers and transmission technology, *data is information converted into binary digital form.* In telecommunications, data sometimes means *digital-encoded information* to distinguish it from analogue-encoded information such as conventional telephone voice calls. Data can often be sent in packets that arrives separately in pieces. Generally, the word data is used for scientific purposes and means a certain number of facts which are somehow linked together.

The Concept of Information

The word Information itself is composed by *in* and *form*, something is put „in-to a form" and seems to be a kind of synthesis between „self *form*ation" and alien induced trans*form*ation. So far, we agree in general terms, with all the authors who define Information as a measure of quantity of form, or as a measure of structural organisation. But it seems that even on the inorganic level of evolution this is only one aspect of the information concept (Weizsäcker 1971).

On the other hand the concept of information is, at least since the works of Shannon and Weaver, closely related to the idea of transformation, emergence of the new or novelty.[3] There is also a large consensus that the concept of information

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[2] Cultural and universal meanings of symbols are well analyzed by J. C. Cooper *in An Illustrated Encyclopaedia of Symbols* and J. E. Cirlot in *A Dictionary of Symbols*.

[3] Shannon and Weaver´s idea of information (see „a mathematical theory of communication, University of Illinois Press, 1964) is strictly related to the aspect of surprise. They don´t relate the concept to any kind of meaning.

is related to the idea of the emergence of difference, which leads us to the concept of bit, as the unit of difference, and so far as unit of information.[4]

Now, if we resume the different concepts of Information actually used, we can find at least the following statements:
Transmission of Information (I) is related to the transmission of Energy (E) and Entropy (S). But (I) is not equal to (E) nor to (S) (Ebeling 1993, Wiener, 1973, Stonier, 1990)
The emergence of Information is only possible *in* self organized systems (Fenzl/Hofkirchner/ Stockinger 1998).
Information reduces the *uncertainty* of a system. Information is a measure for *difference* (Shannon, Weaver, 1949)
Pragmatic Information requires novelty (in the sense of Shannon) and receptivity (Weizsäcker 1979)
Ayres (1994) distinguishes between two basic forms of Information:
D-Information (D - doubt)
SR-Information (SR - survival relevant)
Information is not matter nor energy (Wiener 1973)
Structural Information measures the complexity of a system (Stonier 1990)

A short resume of the literature about Information theories shows that we can identify the following most commonly used concepts:
structural Information
potential Information
kinetic Information
actual Information
pragmatic Information
bound Information
free Information
functional Information
In a very general way, all these concepts can be grouped basically into 3 different types of Information.
Structural Information (Ist). Information, which represents the structural organisation or the functionality of a system like bound Information for example.

[4]Bit: „binary digit“ originally used by C.E. Shannon. See also W.Gitt „Information gehört zum Wesen des Lebens“, Technische Rundschau, Nr.47, Nov. 1989, Bern. and T.Stonier, „Information and the Internal Structure of the Universe“, Springer, 1990, p.32

Pragmatic Information (Ipr). Information, which represents the way how systems move, act or appear at a mesoscopic level for an external observer. To this group we can count kinetic, pragmatic and actual Information.
Potential Information (Ipo). Information that exists only in potential form, such as a set of signs not yet organized to Information.

It is important to point out, that we assume that emergence of irreversible differences in evolution shows a consistent internal logic: we need to admit some logical relation between the past, the present and the future to be able to talk about information. This step leads us directly to irreversibility and probability as basic parts of evolution and of the concept of Information (Prigogine/Stengers 1993).

Emergence and Self-Organisation

After these general statements, we will try to answer the following question: For what reason does a certain number of open systems start interacting in a coherent way, producing new structures, building up cohesion and new structural boundaries? At the beginning we would like to focus on the difference between emergence and self organisation.

The concepts

Emergence is the *appearance of a new property* of a system which cannot be deduced or previously observed as a functional characteristic of the system. Generally, higher level properties are regarded as emergent. For example, water has emergent properties different from its interconnected parts (molecules of H and O). These properties disappear if the molecules are separated again. Like Crutchfield (1994) said, "the whole is greater than the sum of the parts." In other words, the whole exhibits patterns and structures that arise spontaneously from the interaction of the parts. Or to use the words of Green (1993): “Emergence indicates there is no code for a higher-level dynamic in the lower-level parts”.

Important aspects of emergence are the so called multiscale interactions and effects in self-organized systems. For example, small-scale interactions produce effects on large-scale structures, able to act back at the small scales. Prigogine (1993) said that macro-scale emergent order enables the system to dissipate micro-scale entropy creation.

Self-organisation means *appearance of new system structures* without explicit pressure from outside the system, or involvement from the environment. In other words, the constraints on the organisation of the system are internal phenomena, resulting from the interactions among the components and usually independent of their physical nature. Self-organisation can produce structural changes maintaining a stable mesoscopic form of the system, or show transient phenomena.

The research on self-organisation tries to find general rules about the growth and evolution of systemic structures, the forms it might take, and seeks for methods that predict the future results of self-organizing processes. As we can see, following these generally accepted definitions, emergence deals with the appearance of new properties, while self-organisation deals with the appearance of new structures. Anyhow, some can easily state that hardly one comes without the other.

The relation between sign, signal, information and data

Since open systems require permanent interaction with its environment to maintain its metabolism, the *input – processing – output* of energy flows are essential and nothing can reach the internal space of such a system without energy flows.

Following the previously discussed definitions, we assume that:
signs are produced (as changes, differences) in the relevant environment by metabolic activities of the system,
signs are carried and transmitted by energy flows as *signals* to be transformed into system specific *information*
information is than stored as structural changes (actualisation of information) and stored in the system as *data*.

We consider that signs are all kinds of changes in the specific environment of a system, which can be transmitted by energy flows and processed by the internal structure of the system. Since the whole metabolic process covers not only input, the output of the system also produces changes, i.e. signs in the environment. These signs are transmitted as signals, or in other words, signs always need to be "traduced" into an energetically transportable form.

The emergence of coherent interaction and self organisation

Now, let´s observe step by step the simplest form of the *emergence of coherency between 2 open systems.* How do two open systems start to interact?

We start with two open systems (A) and (B), part of the same space-time without any initial relation between each other. Each system operates with its own field of interaction (FI-a) and (FI-b) maintains its specific energetic metabolism. So, whatever triggers the two systems to a coherent interaction, the basic reason is the necessity to sustain its energy flows. This means that the two systems need to share and exchange something to guarantee this basic condition. In other words they need to cooperate.

On the other hand, the metabolic activities of each system cause permanent changes, ("planting signs") in its fields of interaction. As stated before, these signs are "something which stands for something else", i.e., the type of structural organisation which caused them. As example we can use geological deposits or fossil structures in rocks caused by extinguished organisms. This means that the system permanently needs to adapt itself to external changes and (at the same time) to impose changes to its environment according to its structural organisation.

Now, what happens in the system during such a metabolic process and how the concept of information is related to it?

1. As stated before, the structural information (Ist) represents the internal organisation of the system structure, the principle on which the coherency and cohesion of the elements is based on and should be understood as some kind of basic „frame orientation" for the elements of the structure[5]. Within this frame all elements are free to choose its individual movement. So, the structure is able to maintain its coherency (and cohesion) and its flexibility to react and adapt itself to the permanent changes of the field of interaction.

2. The totality of all environmental changes (signs, Sa) caused by the metabolism of the system (A) is called potential Information (Ipt) of (A). The totality of all environmental changes (signs, Sb) caused by the metabolism of the system (B) is called potential Information (Ipt) of (B). The term "potential" is used to underline the fact, that these signs are rather some kind of „pieces" of information than information in the strict sense of our definition.

3. As we know, open systems need to import energy and matter (E-m) in a certain quality and quantity and export (E-m) in inferior quality. The input-flow of energy (and matter) imports signs (changes, events, differences..) from the interaction field as signals which are decodified by the system structure. This process produces re-adaptation of internal structure and actualization of (Ist). The incoming signals must show a minimum of compatibility with the type of structural organisation and the type of its elements. Otherwise, external changes would not be able to cause actualization of (Is). Actualisation of the structural information

[5] Using the appropriate term of John Collier.

produces structural changes which correspond to an addition of data to the former (Ist).

4. The process of actualization organizes signals to system-relevant information produces some reaction and changes at the level of the structural boundary, which follows a different logic as the internal dynamics of the elements, which are „submitted“ to the frame orientation of (Ist). The principles which guide the changes at the level of the system boundary in consequence of structural actualization, we call pragmatic information (Ipr) . The whole body of a system acts in a different way as the parts of which it is composed of. For example, a complex molecule has different qualities and different ways to interact with its environment as the way individual elements interact. As a consequence of the process of actualisation, the system starts interacting differently with its environment.

5. Pragmatic information (Ipr) produces new changes in the interaction field by setting new signs. So we can describe a whole cycle of the feed-back process and see that structural and pragmatic information form a kind of dialectic unity. Their relationship is intermediated by the structural boundary of the system. The first one acts at the microscopic level and the second on the correspondent macroscopic level of the system.

Now we will analyze the situation of the two systems when they approach to each other and their relevant environments begin to overlap.

The first and basic condition to establish a coherent Interaction between two (or more) open systems is accomplished if there is some overlapping of their interaction fields. This so created common space has the function of a channel and can be compared to a „pool of signs“, shared by both systems (A) and (B) which is continuously provided with new signs (Sa and Sb) by the specific metabolic activities of (A) and (B).

Once the channel is established, all participating systems import signals from commonly shared signs. For example, (A) imports signals from signs produced by (B), the imported signals are decodified and the structural Information of (A) is actualized. If the following pragmatic reaction of (A) “traduces” at least partly, the signals received from (B) we can say that (A) begins to react on (B).

If we consider, that the same process occurs in (B) with respect to (A), the first step towards a coherent interaction between both systems is accomplished. Now, each system reacts to the other in its specific way, but they have at least two main possibilities in common: attraction or repulsion with all possible intermediate reactions. In the case of attraction, systems with compatible reactions start to „behave“ in a coherent way and can establish cohesive links.

Finally we can say that open systems don´t need to be in direct structural contact to interact; self-organisation is intermediated by processes beyond their respective structural boundaries and by corresponding internal changes:
the exchange of energy and matter with their relevant environment
the permanent actualisation of structural information and production of pragmatic information

Conclusion

To maintain the necessary flexibility to survive external changes, open systems must be able to respond internally by reorganizing its micro-state and externally by organizing their environment (macro-state) according to their own patterns of structural organisation by setting signs, the smallest possible changes that structural transformation (movement) is able to imprint to its environment.

So, structural Information is transmitted in ”small energetic units” (signals) and must be ”re-assembled”, or in other terms, decodified by the structure of the receiver system. The exchange of signals between systems needs some *overlapping* of their respective relevant environment to create channels, able to transmit the signs through the activity of its metabolism. The incoming signals are classified:
Signals without any importance for self-organisation and reproduction of its specific movement.
Signals which may be import for some systems, but cannot be decodified.
Signals with survival relevant character. These signals are compared to the already ”embodied” structural information and classified in useful or harmful for self-organisation (Ayres 1994). We also can say in a more ”physic” way, that the incoming signals (p.ex. waves) are modifying - and being modified by - the system-specific organisation of matter.

Finally we state that:
1. All natural open systems contain structural information according to their specific type of organisation. This is independent of any observer.
2. The interaction between open systems is ultimately based on exchange of pragmatic information, which cannot be transmitted *directly* like a ”copy”. Pragmatic information must be *decomposed* into signs, transmitted as signals through channels and *(re)assembled* by the receiving system.

3. S*urvival relevant* signals can be classified and organized into pragmatic information by the receiver system according to it´s specific structural organisation. So far, signals are ”understood” and the reorganized structural information obtains a system-specific *sense.*
4. During this process, the energy flow carries signals, based on signs which stand for the organisation pattern of the transmitter-system, into the receiver. Even if the created information has a system-specific sense, the signals establish some kind of ”basic language” which makes interaction between systems possible.

References:

Atkins P.W. (1984) *The Second Law*. Scientific American Books.

Ayres, R.U. (1994) *Information, Entropy and Progress*. AIP Press

Cirlot, J. E. *A Dictionary of Symbols*.

Cooper, J. C.: *An Illustrated Encyclopaedia of Symbols*

Crutchfield, J. P. (1994) *Is anything ever new? In* G. Cowan/D. Pines/D. Melsner (Eds.) (1994) *SFI studies in the sciences of complexity XIX*. Mass. Addison-Wesley

Fenzl,N./Hofkirchner,W./Stockinger, G. (1998) *Information und Selbstorganisation*. Innsbruck. Studienverlag

Gitt, W. (1989) *Information gehört zum Wesen des Lebens*, Technische Rundschau, Nr.47, Nov. 1989, Bern.

Green, D. G. (1993) *Emergent behaviour in biological systems*. In: D. G. Green and T. J. Bossomaier (Ed.) (1993) *Complex Systems - From Biology to Computation*. Amsterdam. IOS Press.

Korzybski and S. I. Hayakawa. *General Semantics*

Laszlo, E. (1987) *Evolution, die neue Synthese*. Europaverlag.

Prigogine, I./Stengers, I. (1993) *Das Paradox der Zeit*. Piper

Shannon, C.E and Weaver, W. (1964) *A mathematical theory of communication*. University of Illionois Press.

Stonier, T. (1990) *Information and the Internal Structure of the Universe*. Springer.

Stonier,T. (1992) *Beyond Information. The natural history of Intelligence*. Springer.

Weizsäcker, C.F. (1971) *Die Einheit der Natur*. München. C.Hansen.

Wiener, N. (1973) *Cybernetics*.

Spinoza, the ”Very Untranscendental“.
Ernst Bloch´s Interpretation of Spinoza

Doris Zeilinger

Baruch de Spinoza[1] (1632-1677) has always been considered as one of the great philosophers by Ernst Bloch, great philosophers being those whose works are connected to the time they live in. Bloch told his students in Leipzig that whereas the problems of a greengrocer today were not much different at the times of Perikles, the problems of a philosopher had vastly changed. “Zeitung und Traktat” (“Journal/Tidings and Treatise”), an essay written in 1923 and published in Logos of Matter (Bloch 2000), is an expression of contemporary thinking, a motive that is recurring throughout Bloch´s works:

Bloch says that only the creative thinker does even in bourgeois times have the strength to be connected to his time. He is a speaker of acting from within, his own thinking transforms itself into the thinking and consciousness of the actors, it informs them about themselves. He continues to say that there has never been a ´pure´ philosopher in the sense of only observing, this would be a bourgeois concept applicable only to the abstract irrelevance of bourgeois actions. Concrete publicity would be the dimension characteristic for great philosophers, feeling the sound of the whole world in every detail. For Bloch, Platon, Spinoza, Kant and Hegel were always masters of the lively time they lived in, masters of the philosophical-political treatise. (Bloch 2000: 18f.)

Bloch devotes two chapters of “Das Materialismusproblem, seine Geschichte und Substanz“ (The Problem of Materialism, its History and Substance) to Spinoza. In the first course, where Bloch deals with “Die Lehren vom Einzelnen – Allgemeinen, den Stoff angehend“ (Doctrines of the Individual – the Universal, concerning Matter“), he mentions Spinoza together with Bacon, Hobbes, Descartes, Leibniz, Hume and Kant as the representatives of the pure general intellectual forms. He discusses the specific limits of these forms, also with regards to the contents. In the second course which is on “Die Lehren von der Materie, die Bahnungen ihrer Finalität und Offenheit“ (The Theories of Matter, its Finality and Openness), Bloch considers Spinoza and Malebranche as representatives of a conception that considers matter as a representation and an expansion-attribute of God. In his Leipzig Lectures (Bloch 1985: 54-117) Bloch deals in more extensive way than in the book on materialism with Spinoza. In chapter 41 of the Principle of Hope there is a passage on “Bruno und das unendliche Kunstwerk; Spinoza und die Welt als Kristall“ (Bruno and the infinite work of art; Spinoza and the world as a

[1] For a characterization see: Bloch (1977f): 174.

crystal) (Bloch 1977: 993-1000). Spinoza is also mentioned sporadically in other parts of Bloch´s works.

Because of Rainer E. Zimmermann´s emphasis on the importance of Spinoza´s philosophy for Ernst Bloch in various publications[2] during the last years, I will explain Bloch´s relationship to Spinoza by a detailed literary exegesis because others as e.g. Jens Scheer see Bloch as part of a specific line of thought, but they exclude Spinoza. Scheer says that Bloch in his ideas on nature and matter referred to the tradition of the ´Aristotelian left´, from Ibn Sina (Avicenna) to lbn Ruschd (Averroes) and Giordano Bruno, finally Schelling and also Marx.[3]

Spinoza passim in the Works of Bloch

As far as I know, Spinoza is not mentioned in the first edition of Geist der Utopie (Spirit of Utopia), but in the second one. Bloch moves the chapter about the "Alexanderzug" ("Alexander Crusade") to the part entitled "Die Gestalt der unkonstruierbaren Frage" ("The Form of the Unconstructable Question") and substitutes the introductory cultural-geographic remarks by an ethical and religious diagnosis of the time. He says that maybe Nietzsche, Schopenhauer and Spinoza, more geometrico, believed enough in what they were saying, but what they all were missing was deep involvement; and he mentions that the day of Damaskus can´t be displaced (Bloch 1977, Vol. 3: 212)

One can interpret a passage from Bloch´s work on Thomas Münzer as a indirect reference to Spinoza. There he says that in essence the fields of Christ, the Unconditioned, and the spaces of the last ratio lie in dawn and in the inner light that still remains contingent; and he mentions that everything that is crystal-like breaks into pieces in view of this and becomes frivolity (Bloch 1977, Vol 2: 182). One can assume an indirect reference to Spinoza here, because Bloch again and again associates Spinoza with the crystal-metaphor. E.g. in the book on Materialism he says that the relationship of the divine attributes with the cabbalistic scope-categories of ´Sephirot´ is obvious, that oriental mysticism together with a philosophy believing in science gives a unique style to Spinozism, that the world is a crystal and the light of God is at the zenith in it (Bloch 1977, Vol. 7: 51). Fifteen years after the book on Münzer, Bloch already sympathises with Spinoza´s ´outwardness´ that he prefers to quixotic internalism (Bloch 1977, Vol. 7: 52). The passage on the crystal in the Leipzig Lectures fifteen years later

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[2] See e.g.: Zimmermann (1990): 39-45; Zimmermann (1992): 31-64; Zimmermann (2001)
[3] Scheer (1994)

shows a continued rapprochement to Spinoza because depth is mentioned as a counterbalance to the crystal. In this passage Bloch describes chill and glow as corresponding to immeasurable, vertiginous depth and a crystal. He says himself that this is a strange combination that has never been mentioned in philosophy (Bloch 1985, Vol. 3: 57)

Spinoza is also mentioned at a place where one wouldn´t expect it, in the last section of the chapter “Ungleichzeitigkeit und Berauschung“ (Non-Simultaneity and Intoxication) in Erbschaft dieser Zeit (Heritage of the Time). In his sharp critique of the behaviour of the Christian churches concerning National Socialism Bloch refers to Spinoza. Bloch says that this church serving after all in a Protestant manner and concordating after all in a Catholic manner, is founded on the bible which is characterised by the new “Leader” (“Führer”) in the following words: “Jewry has always been a nation of a definite racial character and never differentiated merely by the fact of belonging to a certain religion. At a very early date, urged on by the desire to make their way in the world, the Jews began to cast about for a means whereby they might distract such attention as might prove inconvenient for them” (Hitler, Mein Kampf, p. 335). Bloch continues satirically that this must mean that the Jews have had no religion, the Greek no art, the Romans no state and that hence the prophets and apostles, Jesus Christ, the early Christians and Spinoza are done for, their destination is settled – what remains is the Hitler church, it doesn´t diffuse the displeasing interest concerning its members. Bloch writes that religion has always involved much deception, but never so much nasty insanity and so much bloody farce. The combination of the New Testament, the Nibelungenlied and the Horst-Wessel-song would be Satanism, but a very poor one (Bloch 1977, Vol. 4: 102).

It´s notable how Spinoza´s works are categorised: He is considered as one of the highest Jewish-Christian authorities; Bloch mentions him together with the prophets, the apostles, Jesus Christ and the early Christians. In his Bloch-biography, Arno Münster shows that Bloch appraised Spinoza not only as systems thinker and philosopher of nature, but also as philosopher of law and religion:

“Cette prédilection d´Ernst Bloch pour une lecture ´subversive´ de la bible renoue bien sûr volontairement avec une tradition philosophique déjà inaugurée par Baruch Spinoza dont le Traité Théologico-Politique (TPP) propose déjà une lecture autre, critique, des Ecritures, ... consistait à mettre les prophéties de l´Ancien Testament au service de l´encouragement à la révolte des opprimés contre leurs oppresseurs.“ (Münster 2001: 305)

"This preference of Ernst Bloch for a ´subversive´ reading of the Bible could in a way be seen as the continuation of Baruch Spinoza´s attempt in his Theological-Political Treatise from the 17th century to found another reading of the Bible that is extremely critical of the theological dogmas ... and according to which it´s up to devote the prophecies of the Old Testament to the encouragement of the oppressed in their revolt against their oppressors".

In Bloch´s book on natural law we first find Spinoza in the chapter on "Nochmals rationalistisches Naturrecht, sein Bezug zur mathematischen Konstruktion und zur Naturreligion" (Again Rational Natural Law, its Relationship to Mathematical Construction and Natural Religion). Bloch there says that humanism has connected the Epicurean contract theory about the origin of the state to the Stoa which holds that the right legal- and state-order is deduced from man´s nature and must be in accordance with world reason (Bloch 1977, Vol. 6: 68). In the doctrine of natural law of the 17th and 18th century that was significantly influenced by Spinozism the believe in an immaculate nature, in "natura immaculata", was considered as a natural idea that is opposed to the nature of pure natural laws as well as to "artificiality". Bloch says that the conformity to law remained to nature, it was utilised by Spinozism in order to prove natural perfection. However the nature of laws more and more becomes a reservoir of an atmosphere of contemporary critique that is even superior to law: the crystal of mathematical physics appears at the same time as Stone of Justness, as a panacea that shall guarantee happiness. The latter would emphasise the not quite rational and at least overreaching assumptions on which the doctrine of natural law was based, but which nonetheless would have had great effects and would have went off after Rousseau (Bloch 1977, Vol. 6.: 72). One can´t miss Bloch´s critical undertone concerning the suitability of the crystal-nature as an ethical system of orientation, a panacea and magical bullet resulting in fairness and happiness. After this appraisal follows a critique of pantheism that has already been mentioned in Bloch´s interpretation of Giordano Bruno. The universal religion that is naturally common to all human beings and that had already been proclaimed by the Stoa and the Arabic scholastics, was revitalised in the 17th and 18th century, e.g. by the English deist John Toland[4] who considered "all-nature" as a divine unit. Highly visible is the reference to Spinoza when Bloch refers to Toland by saying that it is this ´all-nature´ that gave not only the anthropological innateness to natural law, but also the most important feature that God becomes nature and deism becomes pantheism. So by the way of natura immaculata Spinoza reappears as the most pronounced representation of the deus sive natura (Bloch 1977, Vol. 6: 74). Whereas rationalistic natural law is based on

[4] Toland´s (1670-1722) main work *Christianity Not Mysterious* was one of the founding works of deism.

the compatibility of regularity to law and the immaculate character of nature, Bloch here reclaims a “latterly difference” that denotes his own position.

He says that the regularity to law of nature served the calm bourgeois need for calculation, whereas the pathos natura immaculata served a revolutionary, anti-feudal and at last even anti-capitalist need; that this difference which can also be seen as one between the ideal of calculus and the impressive ideal of nature can be found in one of the main books of this epoche, Holbach´s and Diderot´s Système de la nature (1770); that in this work Spinoza and Rousseau clash in a very instructional manner, this clash could also be seen as one between the value-free regularity to law of nature and the deduction of all values from nature. This would also be reflected in the contrast between the main part of the work and the closing words – in the main part everything that is anthropomorphic and even everything that is valuing is disclaimed and it is at last even hold that order and disorder don´t belong to nature, whereas in the closing part which was written by Diderot there is a focus on nature and its code is considered as the essential source and schoolbook of human rights (Bloch 1977, Vol. 6: 74f).

Spinoza is also mentioned in the chapter on concepts of freedom (freedom to choose, freedom of action, ethical freedom and religious freedom). Ethical freedom concerns the ultimate immanent level of independence (Bloch 1977, Vol. 6: 180) – the concept of immanence referring instantly to Spinoza and one shouldn´t forget that in the sense of a further enhancement religious freedom follows with reference to Kant and Hegel. The ethically free human being dominates passion and impertinence. Bloch says that in the works of Sokrates and Spinoza this ethical will is coined by an idiosyncratic intellectualism: Sokrates says that a right understanding of virtue is liberating, in this context Spinoza teaches that “will and understanding are one and the same” (Ethics II, prop. 49, corollary). This would mean that adequate ideas alone should result in the liberation from the enslavement by inadequate instincts and inadequate circumstances and that they guarantee homo liber in an ethical sense. The topos of this ethical freedom that is unbribable and distant from all quietism is the public realm, not the private one. Bloch says that Spinoza´s homo liber who is absolutely theologically-politically mauling, is in his public steeliness in opposition to privacy and this would latterly mean understanding as will and not just the other way round (Bloch 1977, Vol. 6: 180f.). The last important passage concerning Spinoza can be found in the book on natural law under the heading “Illusionen im bürgerlichen Naturrecht” (Illusions in Bourgeois Natural Law). Bloch is here dealing with the equivocations of the concept of natural law following the phenomenological semantic analysis of

Spiegelberg[5]. The latter distinguishes three epistemological concepts of natural law: the naturally innate (naturangeboren), the naturally insightful (natureinsichtig) and the naturally revealed law (naturoffenbart). Ontological concepts of natural law are the naturally permanent one (naturbeständig), the one that accords to a natural state (naturzuständlich), the one given by nature (naturgegeben), the one valid to nature (naturgültig), the one that is given grounds for by nature (naturbegründet) and at last the law that is according to nature (naturgemäß). Spinoza´s works are connected with the concept of law that is given grounds for by nature.

Bloch says that law that is given grounds for by nature is not given by nature and is not valid to nature, but it has in nature its objective cause and can epistemologically be deduced from the concept of nature that corresponds to it. Here the concept of nature would run from the ´essence´ or the ´nature´ of a thing to the complexity of a panlogistic emanation. Deductions of ´nature´ from rent, bargain, despotism, casus, modus and culpa could already be found in Roman law. Deductions from the world logic and its highest principle could be found during the whole Enlightenment, most of all in the works of the leading behemoths of rationalism Spinoza and Hegel (Bloch 1977, Vol. 6: 211).

In Bloch´s work Subjekt-Objekt. Erläuterungen zu Hegel the two "leading behemoths of rationalism" come across occasionally, they are not only connected by this label of Bloch because he says that for a long time both were considered as "dead dogs" („tote Hunde")[6]. In one of many passages Bloch points to the "vitalistic misunderstandig" of Spinoza by the romantic-historical school (Bloch 1977, Vol. 8: 66f.). The already familiar topics along with the ambivalent assessment are again mentioned. In his interpretation of Hegel´s Science of Logic, Bloch mentions the identity of essence and appearance in Spinoza´s works. He

[5] Spiegelberg (1935): 259ff.

[6] see ibid.: 380: Bloch says that at a whole Hegel was treated by the German bourgeoisie like a hundred years before him Spinoza was – like a "dead dog". Hegel himself mentioned in the chapter on Jacobi in his Lectures on the History of Philosophy that "Jacobi asserted Lessing to be a Spinozist, and gave a high place to the French – this serious statement came to these good men as a thunderbolt from the blue. They – the self-satisfied, self-possessed, superior persons – were quite surprised that he also made retensions to knowledge, and of such a ´dead dog´ as Spinoza" (Hegel: *Lectures on the History of Philosophy,* translated by J. Sibree, 1872). In a comment and critique on Büchner, Frederick Engels in the appendages to his *Dialectics of Nature* refers to this passage from Hegel (see F. Engels: *Dialektik der Natur*, MEW, Vol. 20, Berlin, p. 480.)

says that the tension between essence and appearance could remain uneclectic due to an excess of dualism and of the disruption of the worldly and essential world as in the works of Platon; or that the tension could be attenuated harmonically due to a connection that was too narrow as e.g. in the works of Aristotle, Thomas who connected the world and God (´Supreme Being´) hierarchically and also Hegel. In Spinoza´s works the whole world of appearance would be in the upright light of essence that he calls substance (Bloch 1977, Vol. 8: 168).

Again there is a clear critical undertone. When even Hegel in his Philosophy of Nature starts raging rationally (Bloch 1977, Vol. 8: 212) and his concept doesn´t live up to the myth of nature and to the poetry of nature, the chunkings into negativity don´t bother Spinoza. Bloch says that in his dialectical system, Hegel had to assume natural qualities in order to explain organic-psychological development from physical nature and the vast world of ciphers that physical nature provides or provided for the experience of landscapes, art, the myth of nature, chiliastic hopes and anxieties. Hegel would have had to assume that such qualifications can´t be dismissed even with Spinozian ´inadequate ideas (Bloch 1977, Vol. 8: 214f.).

In the third part of Subject-Object, “Hegels Tod und Leben“ (Hegel´s Death and Life), Bloch´s pros and cons ad Spinoza are very significant. He says that the latterly statics is without salvation for Marx as even not only the procession of ghosts, but also the process were true. It would renew all disadvantages of Platonism and of Spinozism without the advantages of a non-spiritual substratum that is contained in Spinozism (Bloch 1977, Vol. 8: 388), which is static, but material. Hence: pro non-spiritual, material substratum, contra statics.

Also in other respect Bloch preferred Spinoza to Hegel. He writes to Adolph Lowe when his appointment to the University of Leipzig was discussed how wonderful and unbeknown it is to live and work unmolested by all curiosity. Fame would come posthumous and would be due to the works, not due to a person. He says that his man and brother in philosophical life has at all times been Spinoza, not Hegel, that he will be known all over the place by going to Leipzig and that this displeases him (Bloch 1985, Second Volume: 777f.). His doubts concerning the professorship in Leipzig and the decision against seclusive work and life have with hindsight proved right.

Spinoza´s “Doctrines of the Individual – the Universal, concerning Matter”

Already the remarks on Spinoza that are scattered throughout Bloch´s works show eventually – or better: basically – an ambivalent attitude towards Spinozian philosophy. If Benjamin´s hypothesis that the Casual is an excellent source of cognition holds true here, will be shown by the explanations on Spinoza in Bloch´s book on materialism. First, we will deal with Bloch´s analysis of Spinoza´s doctrine of the relationship of the individual and the universal.

Bloch says that in the new thinking the individual gained major importance and that more than ever what was requested was the language of things instead of dark words and general concepts (Bloch 1977, Vol. 7: 45).

A way of thinking turning to the outside is devoted to the individual perceptible by the senses, a thinking that wants to perceive the individual by letting the individual itself get a word and by temptingly questioning the individual. Bloch´s epistemological position is that thought would have to start at the sensory perception if it doesn´t want to end up in idealism. The beginnings of this thinking were difficult, as e.g. in Bruno´s works who practised such a thinking, but never explicated it. Quite the same problems are encountered by newer representatives such as Francis Bacon (1561-1626) in his Empirical Science which has according to Bloch the right lust for the individual, but the art of finding it remains vague.

The answer to this problem actually was mathematics. Bloch says that by the methods of calculation the sensual individual was decomposed into its simplest parts (Bloch 1977, Vol. 7: 45). The price that had to be paid for this long awaited, finally discovered availability of the individual is well known, the qualitative individual disappeared in it just like the former recumbent, classified ´form´ (Bloch 1977, Vol. 7: 45). Quality and form would have been lost in this progress towards the individual. The law, the universal of causal relationships, replaced the universality of the species or the ´form´. This might have been necessary and inevitable, but arguing morally this shortcoming shouldn´t have been simply superseded and forgotten[7]. Bloch argues that Bruno got rid of the pre-eminence of the form an treated contemptibly the form that was connected to the hereafter. Autarkic would be matter that fertilises itself, that spreads out its forms towards the universe and explicates itself" (Bloch 1977, Vol. 7: 510). This would result in the fact that one can´t really substantially distinguish matter from form. In this passage of the Bruno-interpretation of Bloch Spinoza is mentioned as a progression towards an intertwining of immanence without disruptions. Spinoza would no longer want to refer terminologically to the matter-form-relationship of Aristotle and the Aristotelian left, instead he would teach a pantheistic unity of substance-attributes (Bloch 1977, Vol. 7: 511).

[7] One has to take into account Bloch´s reference that Thomas Hobbes has dropped sorrow into the mathematical-general quantity at the beginning of its triumph. Hence the construction of the regular movement of bodies would have nothing to do with the real single movements of the bodies (see Bloch 1977f: 46f.)

Since Descartes the problem of categories has aggravated (Bloch 1977, Vol. 7: 47). What´s the severeness of this problem? Bloch is concerned with the relationship of external and internal world and of the universal and the individual, i.e. with the appropriateness of cognition. He says that Descartes started with the most well known dubito of the world, but the mathematical God that can´t trick someone would have uncovered the existence of the external world as well as of the universal concepts inherent in it (Bloch 1977, Vol. 7: 47). Here we find the external world as the bearer of universal concepts and this shall cover the mathematical construction. The lawlikeness and functional character of the universal is transferred also to the individual as an element of movement. The sensual perception of the individual remains qualitatively. Starting with Spinoza, what happens to this battered individual?

Bloch says that objectively the particularity as pure mode ran into the great new scope-categories of expansion and consciousness. Single bodies would be modes of expansion and would only differ quantitatively, the single spirits would be modes of consciousness and would differ by the latter´s degree. The plurality of modes although it would mainly exist quantitatively, wouldn´t be deduced, and not even the attribute-like dualism of the substances would be (Bloch 1977, Vol. 7: 47).

Now Bloch criticises Spinoza´s believe in intellect. In Descartes´ works which were polemically criticised by Spinoza, doubt was still present, but in Spinoza´s works doubt has disappeared[8]. Knowledge and law rule Spinoza´s world. This results in a believe that is made up of knowledge that has never existed before and all ambiguity and volition disappeared (Bloch 1977, Vol. 7: 48). Spinoza unites the mysticism of the inner immersion into the All-one and the calculativity of the developing thought more geometrico (Bloch 1977, Vol. 7: 48). The individual is of decent, necessarily restricted importance. Bloch says that only sensual perception knows individuality, but as something that is apart from it, whereas adequate

[8] E.g. concerning the mutual relationship of soul and body claimed by Descartes, Spinoza says: “Indeed, I can hardly wonder enough that a philosopher who firmly asserted that he would deduce nothing except from principles that are self-evident, and that he would affirm nothing except what he perceived clearly and distinctly, and who reproved the Scholastics so many times because they wanted to explain obscure matters by occult qualities, should put forward a hypothesis that is more occult than any occult quality.“ (Spinoza referring to Descartes´ thesis of the interaction of body and mind inside the pineal gland.; Spinoza 2000: part V, praefatio).

cognition only knows the regular sequence of everything due to reasonable grounds (Bloch 1977, Vol. 7: 48) – Bloch questions cognisable ´properties´ of the ground[9]. For Spinoza, in cognition as well as the worldly process, with mathematical necessity all things result from the essence of God just like one can deduce the properties of a triangle from its definition.

"The order and connection of ideas is the same as the order and connection of things"[10].

Bloch stresses several times that Spinoza can only set up his great system because he´s missing the concepts of force and movement and hence falls behind already existing mathematical and scientific results of Galilei and Descartes.

Bloch says that the ideal ordo et connexico in the series of ideas (the sequence of grounds of knowledge) corresponds so perfectly to the ordo et connexio of the series of things (the sequence of real grounds) because both sequences of attributes (the ideal one of the cogitatio and the real one of the extensio) exist and develop themselves purely geometrically (Bloch 1977, Vol. 7: 48).

Bloch interprets this as impertinence of the cogitatio to the extensio, as a result the extensio would indemnify itself by the primacy of space in all types of development and according to the analogy of substance and geometric space (Bloch 1977, Vol. 7: 48), where space is an ethical category in calmness (Bloch 1977, Vol. 7: 49).

This would bring Spinoza close to the old, ancient pleasure in species and statics, but with the novum that the universal connects itself with geometric space and the individual connects itself even if not with the parts, so with the ´modifications´ of space. And this would result in the fact that the individual is subsumed to quantity. Bloch says that in this system there are neither independent individuals nor their intensities (Bloch 1977, Vol. 7: 50). Bloch anticipates possible objections to this "de-individualisation":

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[9] Bloch defines the ground as that-ground (from where?) and as final-ground (whereto?), i.e. intensive, hence alogical. This separation of the ground makes it possible for Bloch to construct a processual tension with a right to object concerning the future and with it he wants to contribute to an explanation of the development of the finite from the infinite.
[10] Spinoza (2000): part II, prop. VII.

He says that the ´homo liber´ which is celebrated in the fifth book of Spinoza´s Ethics doesn´t run counter to that because human freedom would only be freedom as an adequate knowledge of necessity, as ´amor fati´. The concept of homo liber would have already existed in the Stoa, but even in a narrower sense than there, it would be connected to the universal world order and to patriarchalistic amor fati in Spinoza´s system. Hence it wouldn´t disrupt the unbreakable determination. Also those single things (res particulares) which are not just phantoms of fragmented perception – even the res particulaes of quantitative perception –, would not have such a relative autonomy as the modes of substance have. Bloch continues to say that this was still true for Descartes, and Descartes had many finite substances and the attributes were the most universal species forms of the substances. Spinoza in contrast knows only one single substance[11] and the attributes are categories of scope underneath substance (Bloch 1977, Vol. 7: 50).

For Spinoza, the relationship of the universal and the individual, of substance and its particularisations as well as of the human being and the unconditioned can´t be determined appropriately by a mode, i.e. by a human being, but only by divine substance which containes all modes (Bartuschat 1993: 919). As a result of this one can find in Spinoza´s works a system of categories that deals with the universal and that has always been rampant in scholastic realism and that there was only circumvented by artificial definitions of the special-being (highest world-being) (Bloch 1977, Vol. 7: 50). This terminology already shows Bloch´s critical attitude, the latter is confirmed by his further statements (“universalism without aniam mea, without a person” etc.). But nonetheless Bloch appreciates the uniqueness of the Spinozian system, although the latter for him is an anachronistic bright light that comes too late and banks on eternity which doesn´t or does not-yet or does never exist in the exhausting richness of being. This seems to be asserted by Spinoza´s last sentence in his Ethics:

“And indeed it must be arduous, since it is found so rarely. For how could it happen that, if salvation were ready at hand and could be found without great labour, it is neglected by almost all? But all excellent things are as difficult as they are rare”[12].

What are the consequences of Spinoza´s thinking concerning the relationship of the individual and the universal for human praxis, particularly concerning the desire

[11] This charge of indivisibility is considered as a misunderstanding on the side of Leibniz, Schelling and Bloch by Rainer E. Zimmermann. See: Zimmermann (1994): 832-839.

[12] Spinoza (2000): part V, prop. XLII, scholium.

for a happy life? The way that the relationship of the human beings and God (the substance) is seen by Spinoza, is revolutionary: God is defined in such a way that with the help of this concept the world and the human being can be fully explained. With this the traditional conception of the ´creatio mundi´ is eliminated, God´s transcendence is denied and the relationship of God to the world is interpreted by making use of a causality that is not founded on the creative reason of God, but in the latter´s nature which is considered itself as a causality, i.e. as a producing power. From this power results the totality of that which is with full necessity and God isn´t concealed behind this power as a mysterious and inexplorable being, but God fulfils itself in it (Bartuschat 1993: 919). Bloch deals with this relationship in the second course and we will return to it below. What also results from the concept of substance is a new image of man.

Bloch on Spinoza´s concept: The human being as part of the world that results necessarily from the nature of God, is no longer an elected creature within the world, but it is reflexion that makes humans different from all non-human being. Hence, human being is in contrast to all other being not only as a mode of divine substance determined by the latter, but in this status of being a determinate mode, it can understand itself out of God and can now also know that what he has already always been. Only this knowledge can be a foundation of action in such a way that the human being is consistent with itself and doesn´t fall for the illusion of a goal that is outside of his reach either within the world or beyond it (Bartuschat 1993: 919).

Spinoza´s "Doctrine of Matter"

In the 26th chapter of the second course in his book on materialism, Bloch analyses Spinozas concept of matter under the heading "Materie, gesehen in Gott; als Ausdehnungsattribut Gottes" (Matter, seen in God; as an expansion-attribute of God) together with the concept of matter of Nicolas Malebranche (1638-1715) who criticised Spinoza in his Méditations chrétiennes (1683). Nonetheless Malebranche was already associated with Spinoza by contemporaries such as Antoine Arnauld (1612-1694)[13]: Arnauld opposed Malebranche´s position that ideas are part of God, which resulted in the position that God is embodied by the idea of intelligible expansion[14]. Malebranche defended himself against this supposed connection of his ideas to the "detestable views of Spinoza", Bloch ties in with this controversy right at this point and considers Malebranche on the one hand as an attempted

[13] Arnauld´s works are voluminous: mathematical, scientific, philosophical, theological works as well as works on grammar.

[14] Rodis-Lewis (1993): 723.

spiritual counter-movement against an irresistible pantheistic materialism (Bloch 1977, Vol. 7: 174f.), but the pathos of ´expansion´ can be found in his works as well as in those of Spinoza and this has caused Bloch´s joint explanation of these two philosophical systems.

In Spinoza´s works we find a primacy of the attribute of expansion – "corporeality, matter" (Bloch 1977, Vol. 7: 176) – opposed towards the attribute of thinking. Bloch considers the note to the second proposition in the third part of the Ethics entitled "On the Origin and Nature of the Emotions" where Spinoza says "that the mind and the body is one and the same thing which is conceived now under the attribute of thought and now under the attribute of extension"[15]. The prevalence of the mode of expansion is for Bloch a result of Spinoza´s decline of free will and the concept of purpose, the latter being a pure mode of thinking for Spinoza. Spinoza´s nature would be dominated by "geometric necessity" and "mechanistic causal nexus": there would be no place for spirits, but also for miracles (due to a prevailing purposive logic of the idea alone) (Bloch 1977, Vol. 7: 176).
Bloch considers the "prevalence of corporeality before all spirituality" as the only possibility for explaining the "strange mixture" of real ground and ground of knowledge in the works of Spinoza[16]. The prevalence of corporeality is not only true for single things, it is guaranteed by divine substance itself because the representation of the world more geometrico would be completely unthinkable, if the ´expansion´ in God itself were not the attribute of all attributes necessary for cognition (Bloch 1977, Vol. 7: 176). The expanded, corporeal-geometrisised God means such a this-life, inasmuch as he lacks passion it´s a "non-anthropomorphic this-life" (Bloch 1977, Vol. 7: 176). Bloch mentions the doctrine of Plotin that in the sphere of the intelligible only the Platonic basic ideas (being, persisting, movement, identity, otherness) are true and if they are present in the world sphere at least "per analogiam" the sensual categories of the divine sphere would remain extrinsic (Bloch 1977, Vol. 7: 39). This doctrine would be the source of the "non-anthropomorphic" God from Maimonides until Spinoza and even in negative theology.

Humans consider themselves as being in the world with geometrically founded necessity and with the mission to comprehend themselves as a part of the world in order to organise their lives according to this. The essence of this world would be "a comprehended expression of metaphysical space". Substance is no longer

[15] Spinoza (2000): part III, prop. II, scholium.
[16] Bloch says that the difference between ground of knowledge and real ground was uncovered "amazingly late" by Crucius; see: Bloch (1977i): 116.

considered as "birthing mother" just like in the works of Bruno, at least as "mixed ground", but as a "crystal-God", "plainly in all clarity" (Bloch 1977, Vol. 7: 176).

On this geometric foundation, Spinoza takes up the doctrine of naturna naturans and natura naturata that can already be found in Averroës:

"In Nature there exists nothing contingent, but all things have been determined by the necessity of the divine nature to exist and operate in a certain way."[17]

In the notes to this proposition, the decisive explanations can be found:

"Before going any further, I wish here to explain, what we should understand by nature viewed as active (natura natarans), and nature viewed as passive (natura naturata). I say to explain, or rather call attention to it, for I think that, from what has been said, it is sufficiently clear, that by nature viewed as active we should understand that which is in itself, and is conceived through itself, or those attributes of substance, which express eternal and infinite essence, in other words ... God, in so far as he is considered as a free cause. By nature viewed as passive I understand all that which follows from the necessity of the nature of God, or of any of the attributes of God, that is, all the modes of the attributes of God, in so far as they are considered as things which are in God, and which without God cannot exist or be conceived"[18].

Spinoza´s natura naturata is for Bloch composed of "mathematical dismissals without purpose", "dismissals" – Bloch even avoids the term "product" which contains a development process, i.e. an active element. This natura naturata is caused by a natura naturans that is without purpose, non-teleological and pure necessity. Although Bloch objected to Spinoza that the latter doesn´t terminologically stick with the matter-form-relationship of Aristotle and the Aristotelian left and teaches a pantheistic substance-attributes-unity, he closes his Spinoza-chapter in the second course with the remark that having introduced the forming powers that were hypostasised as something divine in the past into matter, is Spinoza´s merit and the "truth of Spinozism". This would have resulted in an "non-spiritual substratum" (Bloch 1977, Vol. 8: 214f.) and would have been made possible by Spinoza´s overreaching emphasis on the universal at the expense of the individual, movement and force as well as by the elimination of teleological purpose. This would bring him close to the ancient passion in the species and statics (Bloch 1977, Vol. 7: 50).

[17] Spinoza (2000): part I, prop. XXIX.
[18] Ibid., part I, notes to prop. XXIX.

Immanence versus Transcending without Transcendence

Without a doubt Spinoza´s and Bloch´s thinking is connected by the striving for finding the first and last cause. Adorno says in 1959 on the occasion of the publication of the extend edition of Bloch´s Spuren (Tracks) that it has always been an interest of Bloch to go beyond the border-line set by Kant´s thing-in-itself.

He mentions that one can see behind every word the will to break through the blockage that since Kant has been set up by the common sense between consciousness and thing-in-itself; the sanctioning of this border-line would be considered as being a part of ideology and an expression of the modesty of bourgeois society in a world that has been battered and has been conversed into things by this society which results in a commodified world that is a world for them. This would have been the theoretical coincidence of Bloch and Benjamin. Bloch would have torn down the boundary-posts due to an inherent desire for freedom and this would have also resulted in the dismissal of the ´ontological difference´ between essence and pure being that would be so common for philosophy and this country. The being-in-existence itself would by a resumption of the motives of German idealism and Aristotle become a force and potency that strives towards the absolute (Adorno 1990: 240).

Bloch´s philosophising has its beginning as well as its end in the human existence: “I am, but I don´t have myself, hence we still will have to become” (Bloch 1977, Vol. 13: 11). One could assume that Spinoza´s critique of Descartes that philosophy has to start not from the self, but from God, even though it´s concerned with the status of the human being, is also true for Bloch. Bartuschat says that Spinoza´s methodology doesn´t analyse given effects for their causes, but assumes an adequate knowledge about a final cause that results in all effects and progressing from which clear and evident knowledge about single things can be derived. These things are not considered as being caused by pure accident, but they are considered as being essentially determined by a cognised cause (Bartuschat 1993: 920). But Spinoza is paying a price for his curiosity concerning the final cause because all moments that can be comprehended don´t belong to his system of concepts (Bendszeit 1974: 906). Bloch doesn´t remove these unclear moments which are for him a sign of the unfinished character of the world from which the being-in-possibility of the world emerges. This can be considered as the knowledge of the “not-yet” of Bloch´s philosophy which is characterised by differentiated dynamics that don´t correspond to Spinozian statics. Both models have anthropological and ethical consequences; at this point Bloch is critical of both

Bruno and Spinoza, although the first knows with his monadology a counterbalance to the concept of maximal universe:

He says that in both philosophical systems there´s no place for human affairs in the universe, for both deus sive nature is resting in itself and has a finished character. Old astral mythology and fatalism can be found, in Spinoza´s work in a more than Stoic manner in his concept of amor fati; there is neither room for humanistic nor for dialectical materialism (Bloch 1977, Vol. 7: 178).

In Bloch´s book on Thomas Münzer there is an even more drastic passage where he says that essentially the fields haunted by Christ, the Unconditioned, which are the spaces of the last ratio, are in a state of dawn, in a still uncertain inner light; everything like a crystal breaks into pieces in view of this and becomes frivolity (Bloch 1977, Vol. 2: 182). The crystal-metaphor[19] is a clear reference to Spinoza, Christ as the Son of man is mentioned, not God. Bloch´s thinking is coined by this inclination for the human being; he doesn´t expect of him Spinoza´s perfection in face of the reality of life that has become historically.

Bloch writes to Adolph Lowe that he´s writing a new chapter for the first book of The Principle of Hope entitled “Tafel der Leidenschaften, gefüllte und Erwartungsaffekte” (Board of Passion, Filled and Affects of Expectance) and says that he again wants to take up the motive of ´definitio affectum´ from Spinoza´s Ethics, but not in a rationalistic manner that ignores nothingness and drives away affects as perturbationes animae instead of illuminating them and doing justice to them by a metaphysical ratio. Besides love the most important affects for Bloch are the affects of expectation (the negative ones: anxiety, fear, fright and the negative decree: despair; the positive ones: hope and the decree that has yet to come: confidence) (Bloch 1985, Vol. 2: 760).

This again shows the ambiguity of Bloch´s relationship to Spinoza. In his Principle of Hope, Bloch has the metaphor of a marble hall for Spinoza´s Ethics, a hall to which Spinoza who was turning so extensively to thinghood (Bloch 1977, Vol. 5:

[19] The crystal-metaphor can also be found in the context with Franz Baader, in the heading of the chapter concerning Oken and Baader as well as in the ´preface´ of Bloch´s book on materialism (“Zu phantastischer Materie als Brandmauer gegen Dämonen und als zukünftiger Kristall bei Baader“, “On Fantastic Matter as a Fire Wall against Demons and as a Future Crystal in Baader´s Works“). In the chapter on Baader, Bloch writes that Baader´s heavenly Jerusalem is nothing else than a new heaven and a new earth, a transfiguration of nature, at the same time matter in the form of a completely upright eschatological crystal (Bloch 1977f: 268f.)

80) added a definition of affects as a sort of alien element. This insofar as – and here Bloch quotes Dilthey – Spinoza as well as Descartes in their theories of affects provide analyses from the outside along with relationships one can´t find in any inner perception (Bloch 1977, Vol. 5: 80). Existential philosophy is characterised by a proximity to affect, whereas pure object-thinking is characterised by a decline of affects, Bloch says that everything that is in affect cum ira et studio, is as ´perturbatio animi´ also methodological and an ´asylum of ignorance´ in Spinoza´s sense (Bloch 1977, Vol. 5: 80).

All together Bloch is considering Spinoza as a pathfinder of German idealism, the latter in misunderstanding Spinozism removing geometry from it and transforming Spinoza´s substance into a cosmic subject-object. Bloch says that the organic renaissance-elements one can find in Bruno as well as Spinoza were taken up, the organic thought of nature was for a last time interpreted in a bourgeois-revolutionary way. The existence of moved matter (earthly spirit, substance) would have been life, not death and in the Spinozism of Goethe and even Schelling there would have still been existence of matter. The fully untranscendental look at the world would have since Bruno and Spinoza heavily influenced and enriched existence and wouldn´t have had to impoverish it (Bloch 1977, Vol. 7: 179).

No kind of materialism today or in the future, also no speculative materialism, can ignore the tradition of the Aristotelian left and its successors, even though the latter considers everything in a pantheistic manner as good and having already appeared: Bloch says the eschatological profoundness runs counter to subjectivism and mechanism without the non-inner conscience of Bruno and Spinoza (Bloch 1977, Vol. 7: 546).

But considering this one had to progress towards the dialectic of subject and object and “the revolutionary equation: substance = subject” (Bloch 1977, Vol. 7: 179) which was postulated by Hegel. Bloch says that in Hegel´s works from the postulated equation of subject and substance results a whole fulfilment-system of historical mediations in such a way that the totality of the Absolute exists not only in abstract manner or in examples and allegories, but also concretely in a permanently adjusting process of symbolic figures of being-for-itself which are becoming ever more real. No longer abstract thinking would be the place for the genesis of categories such as in mathematics and formal rationalistic systems, but the ´method´ would be a true one going along the path of history as the organon of concrete philosophy (Bloch 2000: 25)

Subject and Substance Today

This desire of the subject at itself could be spoiled by newer scientific results which put forward the ideas that the human species is not the final and not the only highest creature in the universe, but that a plurality of different forms of existence beyond human existence can´t be precluded, that from an evolutionary point of view this in fact seems to be quite a necessity and that hence the human being is only a relatively unimportant, transitory by-product of matter (Zimmermann 2001: 58).

Starting from these scientific result which are presented in the part on philosophy of history of his recently published, illuminating work Subjekt und Existenz. Zur Systematik Blochscher Philosophie (Subject and Existence. On the Systematics of Bloch´s Philosophy), Rainer E. Zimmermann analyses the compatibility of recent scientific insight and Bloch´s philosophy of nature which from a scientific view has proved to be especially capable of dialogue and a productive instance. Zimmermann quotes one line from Bloch´s Tübinger Einleitung in die Philosophie (Tübinger Introduction to Philosophy): "The world is an experiment that this matter performs with itself by means of us" (Bloch 1977, Vol. 8: 281).

As always in the works of Bloch, he also stresses in this passage ("by means of us") the special position of the human being in the worldly process, not in the sense of a solipsistic subjectivism: The human being is the possible obstetrician of the new, the decisive "factor of innovation" in the active development, not just passive unfolding of the worldly with the purpose of an alliance of humans and nature with a prevalence of human purposes.

Zimmermann says that from today´s point of view he´s not fully satisfied with Bloch´s formulation and hence he proposes a ´proper´ formulation:
"The world is an experiment that substance performs with itself by means of us amongst others" (Zimmermann 2001: 58).

Noticeable is not only the new modesty ("by means of us amongst others") – it is astonishing that Bloch´s "matter" is substituted by Zimmermann´s "substance" in a Spinozian manner. Introducing his "new version" of Bloch´s sentence, Zimmermann writes that matter (according to recent results of the sciences) can´t be substance, which is one aspect of the onto-epistemic mediations of the worldly and its foundation (Zimmermann 2001: 58). Besides the fact that it´s questionable if Bloch had agreed with the view that philosophy should orient itself on the single sciences and that it hence depends on them[20], a short clarification of the substance-concept as it is used here is necessary.

Let´s start with the “scandal of modern philosophy” (if Bloch would have followed such a modernism remains an open question). Zimmermann says that by orienting itself on a fundamental single science (physics), i.e. by making use of ´non-philosophical means´, modern philosophy is reaching an elementary, philosophical decision in favour of materialism. And it would have to do so in order not to violate fundamental philosophical theorems such as the theorem of foundation and Okham´s razor (Zimmermann 2001: 152). Simple insights from physics that enforce such a decision are e.g. related to the ´cosmological principle´ that hold that physics is the same everywhere in the universe. History of the cosmos can be described as a history of increasing complexity. Starting with the Big Bang, during the course of development new structures emerge in the universe which are real innovations. The basic substratum of the universe (space-time-matter) doesn´t at all change during these processes, nothing emerges and nothing disappears. Only the complexity of the produced systems increases permanently. Assuming this, human cognition is nothing else than a late complex system of space-time-matter. “Cognition is a form of matter” (Zimmermann 2001: 151).

Then there is the differentiation between substance and substratum: Substratum is space-time-matter, and the latter is worldly. Bloch agrees with this: he conceives matter by referring to the Aristotelian differentiation of matter as capable of development and there is a strong emphasis on openness (“process-matter”) that seems to collide with the cosmological principle which holds that nothing new emerges in the world process, but this is a little bit dampened by the concept of latency:

“matter is the real possibility for all the forms that are latent in its bosom and are unbound by the process... Real possibility from there on [the Aristotelian ´dynamei on´, D.Z.] can be understood as substratum” (Bloch 1977, Vol. 5: 271).

Bloch´s starting point for the conception of the process-matter is again the human being and his history. The dialectical-materialistic moments of development such as subjective factor, mature conditions, transformation of quantity into quality, even changeableness (Bloch 1977, Vol. 5: 273) must prove themselves in matter. Based on a “block-matter” they would be without a substratum. Bloch says that the transition from the realm of necessity to the realm of freedom only finds its place

[20] see Rainer E. Zimmermann in succession of Theunissens, e.g.: Zimmermann (1998): 151.

in incomplete process-matter and that the extremes future-nature, anticipation-matter become united in historical-dialectical materialism (Bloch 1977, Vol. 5: 273).

How does the concept of substance differ from that of substratum within the framework of the ongoing discourse? In fact, this difference can be visualized when thinking of (classical) relativity theory on the one hand, and quantum theory on the other as two aspects of the same underlying unified theory which has not been found yet. This would be a "theory of everything" (TOE) for which quantum gravity is the best candidate at the time. Hence, it is always one and the same (single) world to which we are referring, and we conjecture that it may be described in terms of one and the same (unified) theory. So the available theories are to this future theory what according to the metaphysical tradition the attributes of substance are to substance itself. Contrary to the latter which cannot be described in (scientific-)theoretical terms at all (due to the restriction of human perception) its minimal mapping in terms of a future TOE can be properly explicated. And the substratum is the physical correlate of this TOE. Hence, substratum and TOE together are the unified description of what humans can express as of substance´s (only) attribute. The substance however must be conceived on one level below, it is considered in the sense of Nikolaus von Kues as “first origin” which is the “simplest and most perfect indivisibility”, this indivisibility being the “cause of everything” (de Cusa 1977: 43).

For Rainer Zimmermann the solution of this problem can be found in the concept of ´pre-geometric´ structures: One already searches on the level of intra-physics for an abstract structure from which the universe expressed as space-time-matter can be deduced in such a way that macroscopic and microscopic physics seem to be two different perspectives of the world (Zimmermann 1998: 152).

Of course this renewed, actualised mathematical illustration would remind Bloch of Spinoza – but it remains questionable whether the mathematisation of substance would erase his basic objections. But one can´t deny that Bloch is close to substance-metaphysics, this doesn´t result in a worldly that can be adequately explained mathematically, but in a disparate worldly that can not-yet be observed by itself and the human being. Taking a look at Bloch´s concept of substance makes clear his position.

Reading Bloch´s systematic main work shows just like his other works a thriftily usage of the term “substance”. I think that this is due to the problem of integrating substance into an open system which he nonetheless tries to do. Substance as that which is in effect at the foundation and can be experienced by humans is present in

latency is substantiality. Its cognisability in the what-being of a content comes into prospect, the whole world process is considered as an experiment thitherto. The already partly realisation of the what-content is considered as a temporary guarantor of this fundamental cognisability and is signified by the term “shining forth” (VorSchein).
In the chapter on the forms of moving out (Auszugsgestalten) in Experimentum Mundi there is a passage on the relationship of matter and substance. All gestalt figures, Bloch stresses, emerge from the dialectical process and from matter as developing, producing[21] substance immanently as well as speculatively (Bloch 1977, Vol. 15: 165) So for Bloch matter is a dialectically developing, producing substance and this substance has an immanent and speculative potential.

How does Bloch define substance? Bloch´s concept of substance is qualitative-processual: He says that the reinforcement of the world question and its content by the human being opens up the transition of the world-things from a stagnant, incrusted thinghood to the fermenting just like to the questioning just like to the overarching, i.e. to the substance. And this would be process-substance which is not a category of transmission, also not a gestalt category because it hasn´t yet reached a brought out form, but rather it is germ and utopian totum of the materia ultima in the laboratory of the world (Bloch 1977, Vol. 15: 246).

For Bloch the important differentiation between substance and substantiality is due to the open system: Substance in contrast to substantiality has as an still outstanding totum no degrees and is in contrast to substantiality not fully at work, it rather stands for fulfilled work and the felicitous identity in the relationship of the That (quod/Dass) and the What (quid/Was), quidditas and quodditas. Substantiality would be its only yet present mode of being. And then the decisive explanation: Substantiality as the mode of being of substance is transformed by the logical principle of identity which hence also formulates the only liable condition of substance in ought-to-be identity (Bloch 1977, Vol. 15: 246).

As postulate substance is also included in the unnegligent principle of hope to which action is bound. Bloch says that seen like this on the process-way related to the political and mainly to totality, there is a close relationship between the principle and the scope-category of periods, the encompassing spheres (especially the ethical) as well as between substance and the gestalt categories as forms of moving out (Auszugsgestalten). Because the principle of a good At-All

[21] the German term used by Bloch is “ausgebären“ which corresponds on the one hand to “bearing“, but not only points at an active production, it also refers to a developing process

(Überhaupt) would transform the gestalt- and even more the scope-categories into categories of an attempted moving out, into a better collective-being (Gemeinwesen), substance-being (Substanzwesen) (Bloch 1977, Vol. 15: 181).

An "all-one", already produced substance would have to express itself in all "modes"; such a qualitative difference as is conceived by Bloch with the "forms of moving out" ("Auszugsgestalten") wouldn´t be possible. Substance in Bloch´s works is not as foundation of the worldly always absolutely identical with itself in the sense of harmonious as wholeness and unity of existing infinity and eternity and in the sense of strict ideality (Zimmermann 2001: 161). Instead he is speaking of the itself-searching-searched (sich-suchend-gesuchte) category of substance (Bloch 1977, Vol. 15: 68) The That unfortunately remains evident by the theorem of foundation and even in it formal-logically unilluminated. This wouldn´t be the case, if the theorem meant with the words of Jakob Böhme the foundation as non-foundation (Bloch 1977, Vol. 15: 76). With "non-foundation" Böhme was referring to the still non-apparent absolute and conceived it as the non-initial One without a predicate where all development has its origin and about which one can positively only say that it is "Nothingness" which is addicted for Something. The will to Something is an essential necessity of the non-foundation because by it "Nothingness" gains existence (Bendszeit 1974: 906).

Hence there is a large affinity of Bloch for Böhme´s non-foundation as the source of being. He surely could also agree with Zimmermann´s figure of identity "contaminated with difference" in substance itself as the foundation of the worldly. But Bloch´s terminology is less value-free, he calls the contaminated difference the evil that can transform itself as a negative reversion into another principle (Bloch 1977, Vol. 15: 181). There is no evidence in Bloch´s works that he didn´t consider substance already in Spinoza´s writings as absolute identity, but as identity of identity and difference as reclaimed by Zimmermann. At a whole it seems like Bloch in a substance-metaphysics of the "universal" sees the danger that the worldly especially the humans and their affairs are degraded if it is considered as refuse of the One as has been done ever since Platon: Opposed to the being-for-itself (□□□`□□□) which exists unrelated and absolutely (□ □□□□□□ □) and is recognised, is the related-being (□□□□ □□□□□) which is in its being related to the being-for-itself, whereas the latter exist independently from the related-being. Based on this is the fundamental categorical differentiation between S(ubstance) (□□□□□) and A(ccident) (□□□□□, □ □□□□□□□□□) which can only exist as determination of substantial being and insofar as its being is related to substantial being. This graduation of the modes of being has to do with the graduation of being in ideas, mental-mathematical being and evidence in such a way that the eternal intelligible (ideas, mathematicality, souls) at a whole possesses the modes of being of the Substantial, whereas the changeable Evident at a whole has the mode of being of the Related and only wins its share of the □□□□□ by the virtue (arete) as the realisation of the what-being so that it is no actual-what (□□), but only a qualified-by-a-what (□□□□□□□□, □□□□□) (Schantz 1974: 497).

Due to the objectively given problems of imagining or conceiving this One or Absolute, for the time being doubts remain concerning the possibility of an all-embracing, depletive explanation as it is provided today by pre-geometry. This of course doesn´t want to question the hermeneutic efficiency for certain purposes. Maybe it is also otiose to make such speculations because this doesn´t change the basic motive of Bloch´s thinking, i.e. the consideration of the worldly as intensive-logical process of tension where from a felicitous end (identity as the result of a processual identification[22]) the origin will illuminate itself or □ importantly □ where the origin will remain unilluminated due to a failing denouement. The world process isn´t determined by a "structurally secluded necessity" where inner and outer conditions coincide as is e.g. as Bloch mentions imagined by Spinoza in his definition of the God-nature as the causa sui, but contingency is also at play in the process, without it there would be no "richness of development". Adorno´s assessment in the essay mentioned above emphasises this aspect: Bloch´s thinking would put forward ´fulfilment´ according to the model of authentic □□□□□ and not as task or idea. Hence it would be anti-idealistic and materialistic (Adorno 1959: 241).
Bloch writes that reference points for human actions are ethical ideals of the coincidence of foundation and manifestation which can be more or less concretely anticipated and that they exist as structural possibility. This possibility would unclose the horizon of the causa sui or the felicitous identity of existence and essence as the most resolute category of salvation, it would be more or less concretely possible to anticipate reference points for human actions. The ideal point where essence and appearance coincide would always be the absolute guideline for the structural line of the humane-positive possible[23].

Bloch and Self-Organisation

Bloch´s philosophy of nature, as it is also present in his interpretation of Spinoza, seems to be a well-suited dialog partner for today´s theories of self-organisation. The reference of Bloch to the concept of natura naturans which conceives nature as a self-producing system, corresponds to and even anticipates fundamental ideas that have been developed by the physico-chemist Ilya Prigogine and the physicist

[22] see Bloch (1977i): 246
[23] all quotations from: Bloch (1977d): 270f.

Hermann Haken in an interdisciplinary approach. Bloch stresses resolutely the character of the openness of the world process with objective-real possibility-horizons. In addition there is the concept of a “hypothetical subject of nature” that enables a dialectical cognition of the process of nature, but also in my view tries to live up to an ontological monism: the human subject has with the hypothetical subject of nature not only a partner for “parallel actions” in the sense of an available structural resemblance, but also even a co-operation partner for alliance in order to advance human purposes which presumably are also the purposes of nature. This concept even transcends the Hegelian dialectic of chance and necessity and possibly the models of the formation of structure present in the theories of self-organisation because there is a strong teleological element constitutive for Bloch´s Experimentum Mundi.

In all that we find the idea of a production “from within” which starts from an “bottom-up”-organisation not only at the core of Ernst Bloch´s philosophy of nature, but also of his practical, political philosophy. In this sense Burghart Schmidt already wrote in 1982 in his essay “Zum Werk Ernst Blochs” (On Ernst Bloch´s Works):

“The determining reasons of history were no longer declared as unalterable laws by Bloch, but understood as open tendencies that can only take their direction of realisation by human beings solidary working at the creation of freedom. Purpose, goal, meaning in this are mediated with the conditional relation of a first and a second nature, so that their determinism and force must not be accepted without dissent. The connection of foundation and goal by work became the main topic of Bloch´s late main work ´Experimentum Mundi´ which insists that there is also liberating order, a bottom-up-order, self-organisation [emphasis added, D.Z.], and order and truth would indispensable be ordered systemically, but open in the attempt-relationships of their contents leading right through and connecting, adjourning, assembling the disciplines of knowledge, art and praxis”.

The dimension of the philosophy of nature in his works, which constitutes Ernst Bloch´s exceptional position in the circle of “Western Marxists“, was immediately realised and picked out as a central theme after his death. The first Ernst-Bloch-Days that took place in Tübingen 1978, dealt with “Marxismus und Naturbeherrschung“ (Marxism and Domination of Nature)[24.] In 1981 the book “Andere Ansichten der Natur“ (Other Views on Nature) of the “Arbeitskreises Naturqualität“ (Research Group Quality of Nature) was published[25.] Several

[24] Sozialistisches Büro Offenbach (1979)
[25] Daxner/Bloch/Schmidt (1981)

conferences of the Ernst Bloch Association discussed philosophical topics of nature, e.g. in 1986 “Wissen/Wissenschaft und Hoffnung“ (Knowledge/Science and Hope[26]), in 1989 “Natur und Praxis“ (Nature and Praxis)[27], in 1991 “Produktive Kräfte und gesellschaftliche Synthesis. Wie gesellschaftliche Bedingungen die Produktivität von Menschen und Natur prägen“ (Productive Forces and Social Synthesis. How Social Conditions and Productivity are Coined by Human Beings and Nature [28]), and in 2000 “Bruno - Schelling - Bloch. Elemente einer Philosophie“ (Bruno – Schelling – Bloch. Elements of a Philosophy[29]). Besides the work of Jan Robert Bloch[30], who as a skilled natural scientist had the question of nature permanently on his agenda, the dialog between Bloch´s philosophy of nature and theories of self-organisation was crucially influenced by the works and projects of Rainer E. Zimmermann, as in the journal “System & Struktur“ (System & Structure)[31] and the “Klymene-Project“[32]. Hence the INTAS-project stands – amongst others – in the tradition of the Bloch-discourse which hopefully will be a quite productive one.

References:

Adorno, Theodor W. (1990) Blochs Spuren. Zur neuen erweiterten Ausgabe 1959. Collected Works, Vol. 11 Noten zur Literatur. Frankfurt am Main. Suhrkamp.

Bartuschat, Wolfgang (1993) Baruch des Spinoza. In: Jean-Pierre Schobinger (Ed.) (1993) Grundriss der Geschichte der Philosophie. Die Philosophie des 17. Jahrhunderts. Vol. 2 Frankreich und die Niederlande. Basel.

Bendszeit, K. (1974) reference „Grund“. In: Joachim Ritter (Ed.) (1974) Historisches Wörterbuch der Philosophie. Vol. 3. Basel / Stuttgart.

Bloch, Ernst (1977) Collected Works. Frankfurt am Main Suhrkamp:

Bloch, Ernst (1977a) Thomas Münzer als Theologe der Revolution. Collected Works, Vol. 2. Frankfurt am Main. Suhrkamp.

[26] Ernst-Bloch-Assoziation (1986)
[27] Ernst-Bloch-Assoziation (1990)
[28] Ernst-Bloch-Assoziation (1993)
[29] Doris Zeilinger (2001)
[30] See e.g. Bloch (1995)
[31] Zimmermann (1992ff)
[32] Zimmermann (1999)

Bloch, Ernst (1977b): Geist der Utopie. Zweite Fassung. Collected Works, Vol. 3. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1977c) Erbschaft dieser Zeit. Extended Edition. Collected Works, Vol. 4. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1977d) Das Prinzip Hoffnung. Collected works, Vol. 5. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1977e) Naturrecht und menschliche Würde. Collected Works, Vol. 6. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1977f) Das Materialismusproblem, seine Geschichte und Substanz. Collected Works, Vol. 7. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1977g) Subjekt-Objekt. Erläuterungen zu Hegel. Enlarged Edition. Collected Works, Vol. 8. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1977h) Tübinger Einleitung in die Philosophie. Collected Works, Vol. 13. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1977i) Experimentum Mundi. Frage, Kategorien des Herausbringens, Praxis. Collected Works, Vol. 15. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1952) : Avicenna und die aristotelische Linke. Appendage to Das Materialismusproblem, seine Geschichte und Substanz. Collected Works, Vol. 7.

Bloch, Ernst (1985) Neuzeitliche Philosophie I. Von Descartes bis Rousseau. Leipziger Vorlesungen zur Geschichte der Philosophie. Vol. 3. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (1985) Briefe 1903-1975. Second Volume. Frankfurt am Main. Suhrkamp.

Bloch, Ernst (2000) Logos der Materie. Eine Logik im Werden. Aus dem Nachlass 1923-1949. Edited by Gerardo Cunico. Frankfurt am Main. Suhrkamp.

Bloch, Jan R. (1995) Die dialektische Struktur der Selbstorganisation (The Dialectical Structure of Self-Organisation). In: Bloch, Jan R. (1995): Kristalle der Utopie. Gedanken zur politischen Philosophie Ernst Blochs. Mössingen-Talheim. Talheimer.

Daxner, Michael/ Bloch, Jan R./Schmidt, Burghart (Eds.) (1981) Andere Ansichten der Natur. Arbeitskreis Naturqualität. Münster.

Ernst-Bloch-Assoziation (Ed.)(1986) Wissenschaft und Hoffnung. VorSchein No. 6. Berlin.

Ernst-Bloch-Assoziation (Ed.) (1990) VorSchein No. 11/12. Berlin.

Ernst-Bloch-Assoziation (Ed.) (1993) VorSchein No. 13/14. Nürnberg.

Münster, Arno (2001) L´utopie concrète d´Ernst Bloch. Une biographie. Paris. Kimé.

Nicolai de Cusa / Nikolaus von Kues (1977) De beryllo / Über den Beryll. Hamburg. Meiner.

Rodis-Lewis, Geneviève (1993) Nicolas Malebranche. In: Jean-Pierre Schobinger (Ed.) (1993) Grundriss der Geschichte der Philosophie. Die Philosophie des 17. Jahrhunderts. Vol. 2 Frankreich und die Niederlande. Basel.

Schantz, R. :references “Substanz”; “Substanz/Akzidens “. In: Joachim Ritter (Ed.) (1974) Historisches Wörterbuch der Philosophie. Vol. 3. Basel / Stuttgart.

Scheer, Jens (1994) Stichpunkte zu Technik und Zukunft bei Bloch and Zu neuem Naturumgang in Neuer Gesellschaft. VorSchein-Hefte. No. 1. Nürnberg.

Sozialistisches Büro Offenbach (Ed.) (1979) Marxismus und Naturbeherrschung. Beiträge zu den Ersten Ernst-Bloch-Tagen, Tübingen October 27th/28th, 1978. Offenbach.

Spiegelberg, Herbert (1935) Gesetz und Sittengesetz. Strukturanalytische und historische Vorstudien zu einer gesetzesfreien Ethik. Zürich / Leipzig.

Spinoza, Baruch de (2000) Ethics. Edited and translated by G.H.R. Parkinson. New York. Oxford University Press.

Zeilinger, Doris (Ed.) (2001): VorSchein No. 20/21. Jahrbuch der Ernst-Bloch-Assoziation. Berlin. Philo.

Zimmermann, Rainer E. (1990) Seinsmangel und Produktivität. Zum Naturbegriff bei Ernst Bloch. In: VorSchein. Blätter der Ernst-Bloch-Assoziation, No. 11/12, Berlin.

Zimmermann, Rainer E. (Ed.) (1992ff.) System und Struktur. Neue Zeitschrift für spekulative Physik. Cuxhaven. Traude Junghans.

Zimmermann, Rainer E. (1992) Axiomatische Systemdialektik als Differenzphilosophie. Zur Denklinie Spinoza, Schelling, Bloch. In: Zimmermann, Rainer E. (Ed.) (1992): System und Struktur. Neue Aufsätze zur spekulativen Physik. Cuxhaven. Traude Junghans. pp. 31-64.

Zimmermann, Rainer E. (1994) Kontinuum und Diskontinuum. Von der spekulativen Logik Leibnizens zur spekulativen Physik. IV. Internationaler Leibniz-Kongreß. Hannover.

Zimmermann, Rainer E. (1998) Rem gerere. Zur Logik der Operationalisierung in der heutigen Philosophie. In: Zimmermann, Rainer E. (Ed.) (1998) System und Struktur. Hauptsätze des Seins. Die Grundlegung des modernen Materiebegriffs. Sonder-Doppelnummer zum 800. Todestag von Averroes. Vol. VI / No. 1 & 2 Cuxhaven / Dartford. Traude Junghans.

Zimmermann, Rainer E. (1999) The Klymene Principle. A Unified Apprroach to Emergent Consciousness. Kasseler philosophische Schriften. Materialien und Preprints. Issue 3. Kassel.

Zimmermann, Rainer E. (2001) Subjekt und Existenz. Zur Systematik Blochscher Philosophie. Berlin / Wien. Philo.

II.3. Biological Systems

Organisation in Biological Systems

John Collier

Biological systems are typically hierarchically organized, open, nonlinear systems, and inherit all of the characteristics of such systems that are found in the purely physical and chemical domains, to which all biological systems belong. In addition, biological systems exhibit functional properties, and they contain information in a form that is used internally to make required functional distinctions. The existence of these additional biological properties is widely granted, but their exact nature is controversial. I will address first the issue of biological function, and then turn to the issue of information in biosystems.

Biological function

In the literature on function in biology, there are two distinct approaches. One, the etiological view, places the origin of function in selection, while the other, the organisational view, individuates function by organisational role. Both approaches have well-known advantages and disadvantages. I propose a reconciliation of the two approaches, based on an interactivist approach to the individuation and stability of organisms. The approach was suggested by Kant in the Critique of Judgment, but since it requires, on his account, the identification a new form of causation, it has not been accessible by analytical techniques. I proceed by construction of the required concept to fit certain design requirements. The etiological view is essentially mechanical, and its closest analogue in science is Skinner´s scientific behaviorism. The organisational approach, on the other hand, uses notions like autonomy and integration that are central to the discourse on self-organisation. This might suggest that the organisational view should be preferred by students of self-organisation, but I will argue that the organisational views that currently dominate that literature are highly rationalist if not mechanical in spirit, and that they suffer from a failure to recognise that creative self-producing systems must be dynamically open, not just having inputs and outputs, but involving interactive dynamical processes with their surroundings. There are two reasons why this “opening” of the organisational view is important. First, the philosophical perspective of self-organisation is intimately connected with an open systems perspective. Second, and perhaps more importantly, if we assume a closed autonomous system, then all characteristics of the system must already be contained within the system. This makes creativity at best a case of novel combination of pre-existing forms, and at worst it means that there is no possibility of anything genuinely novel coming into existence at all.

Here is an outline of the two approaches:

Etiological/causal

The etiological account of function explains the function of a trait in terms of its origin, i.e., a trait´s function is to F if and only if the trait exists because it Fs: e.g., the heart´s function is to pump blood, since the heart was selected for its blood pumping.
• adaptations – traits are selected for their survival value
• artifacts – traits are selected because they fit some design goals
This is the standard account in current biology. "neoDarwinist" as mentioned above it is most similar to "scientific Behaviorism", in that it focuses almost exclusively on inputs, outputs, and the reinforcement of their relations.

Examples:
Larry Wright – original formal model
Dawkins, sociobiologists, optimality theorists, genic reductionists – implicit or explicit selectionism
Robert Cummins – minds, behavior Cummins is a bit of an exception, since he pays attention to organisational role, but his model has the mechanistic character of the etiological models.
Ruth Millikan – language, semantics – meaning is ultimately grounded in biological function.
Karen Neander – proper functions – the proper function of a trait is given by what the trait was selected to do.

Essential properties of such approaches are: Externalist: Function is externally imposed (design or selection for), and is determined by external relations. The process is a mechanical one of retention or elimination of specific characters (traits).

Organisational/formal

The organisational account explains the function of something in terms of its role in maintaining an organisation: e.g., the heart is functional because it plays the role of a pump in the blood circulatory system of an organism thereby supplying nutrients and removing wastes as required for the survival of the organism.
• adaptations – functional traits are adapted in that they are selected for their contribution to an organisms viability
• artifacts – parts of artifacts are chosen because of their role in the overall design of the artifact

This is a more traditional account that has more recently been revived with new precision. Roots in Aristotle and Kant.

Examples:
Rosen – closure to efficient causation, relational biology, MR accounts of embodiment in material causation
Maturana and Varela – autopoiesis, phenomenological approach to the mind, closed to information

Essential properties of such approaches are: Internalist: Function is internally produced, and is determined by internal relations that contribute to overall telos.

Relation of the Accounts

a. Incompatible alternatives (inconsistent on the facts):
The two accounts are different and competing explanations of the same phenomena, and can be distinguished by objective empirical tests.
b. Incommensurate alternatives (different paradigms):
The two accounts are so different in their fundamental assumptions about the nature of function that no empirical test will be accepted by both sides as an objective test
c. Complementary perspectives:
The two accounts are not really in competition, but give complementary and compatible explanations of the same phenomena, and together can give greater understanding
d. Complementary domains:
The two accounts are not really in competition because they deal with different aspects of function, and neither alone is empirically complete

The truth is probably that some combination of the above occurs.

Relative Advantages of the Accounts

Shared:
i. Both can give a unified account of both adaptations and artifacts
ii. Both claim completeness
iii. Both claim to account for embodiment of function
iv. Both claim to account for teleology of function by reference to some ultimate end. 1. for design this is intentional (represented goal -- teleological) 2. for selection this is survival (implicit goal -- teleonomic)

Etiological Approach:
Advantages
i. selection determines the “proper function” of a trait
ii. functionality is directly related to efficient causation through the causal process of selection
iii. mechanism is simple
iv. functionality involves interaction essentially
Disadvantages
i. proper functions change, but origin doesn´t – exaptations, preaptations
ii. teleological aspect is weak without design
iii. integration of function appears to be relatively accidental
iv, mechanism is simple
v. functionality can be detected without knowing history in most non-contentious cases

Organisational Approach:
Advantages
i. functionality is directly related to goals through the satisfaction of a requirement
ii. functionality is necessarily holistic and organic
iii. changes in functionality always involve changes in organisation
Disadvantages
i. functionality is diffuse, except in explicit design, e.g., bird´s wing versus airplane wing and propeller
ii. unclear how functionality can arise without organisation, but also vice versa – “chicken and egg” problem
iii. organisation is only loosely tied to embodiment – very different structures and processes can embody the same function; worse, it seems that many different organisations can satisfy the same function by having the same inputs and outputs
iv. following from iii, the relation between organisation and causality is unclear.
v. also following from iii, the internal organisation seems to be irrelevant to input/output functionality

Synthetic Account of Function

1. We need an account of function that combines internal and external aspects, since both are important to functionality. The account must include both the open (interactive) and closed (organisational) aspects of functionality.
2. The account should include both the teleology and the holistic aspects of the organisational account with the causal and modular aspects of the etiological account, inasmuch as possible.

3. The account should avoid vicious circularities and infinite regresses, both logical and generative.

To satisfy these requirements, I use a bit of *conceptual engineering*, some applied metaphysics. Usually, philosophers would analyse the meaning of pre-established ideas, and test these analyses against our intuitions about meanings. I am not a usual philosopher, though, and my aim is to produce a concept that fits some established requirements, but for which there is not a pre-established meaning. Part of the problem, in this case, as Kant observed, is that the old ideas just won´t work. Analysis alone can only take us in circles.

The design requirements are:
• 1. requires that the account of function is dynamical, to preserve the interactive aspect, but functionality must essentially involve organisation as well. We are therefore talking in terms of process organisation, or organised processes. These processes must be closed in some way, but must also be open interactively; requiring process closure of sort, but also interactive closure, if interaction is to be part of the organisation.
• 2. requires that there is some holistic entity that functionality is for. An account of functionality must identify this entity.
• From 1. and 2. together, this entity is characterized by organisational process and interactive closure.
• At the same time, processes must be integrated in some way, but not so integrated that they can cannot vary in different causally independent dimensions (otherwise we will run into problems of logical or generative circularity).

Thus, minimally, we need a notion of individuation or unity based in an open system organisational process closure in which the process closure results in the viability of the very system it individuates. We could abbreviate this to OSOPC-PCVSR, but for convenience our research group calls it *autonomy*, because it corresponds to many central pretheoretic ideas about autonomy. I caution, though, that the issue of whether or not the constructed idea is *really* autonomy is not the issue, and is really more than a little beside the point.

Some features:
• Autonomy is both open and closed.
• Autonomy requires conditions that explain closure, but permit openness.
• Furthermore, autonomy is closely related to individuality and self-governance, the combination of the two yielding independent functionality through the organised interaction of processes.

• Varela (1979) invokes a duality between structure and organisation that sets up the problems of multiple implementability that follow from the complete informational closure of organisation.
• In the autonomy approach, processes and their interactions, which are themselves further processes, form the fundamental basis, and organisation is a direct property of this network of processes.
• There is no duality between the informational and the causal on this model.

Critique of the Autopoietic View

The problems with the etiological account form the perspective of self-organisation theory are well known. I won´t go into them in any detail here, except to note that the account is mechanistic, and organisation plays no central role, though it is one of the most obvious traits of organisms. Obviously, something is missing from the account. One of the main versions of the organisational approach is the autopoiesis of Maturana and Varela. Another is the closure to efficient causation of Robert Rosen. They both have the advantage of making organisation central, and as such is a great advance over the etiological approach. Nonetheless it also suffers from mechanism, mostly because of its closed, internal character. Self-organising systems are intrinsically open systems, and if information is a central aspect of organisation, which it surely is, autonomous biological systems must be open to information as well as energy and matter. This is denied by the definition of autopoiesis.

Maturana and Varela, in their early work, clearly make autopoiesis necessary and sufficient for life, and also make it completely closed (e.g., Maturana and Varela 1980, Varela 1979). In later work, however, the notion of autopoiesis gradually disappears, but its ghost remains. There is a similar notion in Robert Rosen´s *Life Itself* (1991): “A material system is an organism iff it is closed to efficient cause” (p. 245).

In this definition, efficient cause is analogous to production rules as used by Maturana and Varela, so we have a similar closure to production. The notion of efficient cause itself arises in Rosen´s rather complex but internally coherent discussion of modeling relations. The basic idea is that the efficient cause of a house is its builder, but in the case of living systems the system is its own builder. Unlike our version of autonomy, but like autopoiesis, it is entirely closed. The notion of efficient cause, however, arises out of a particular view of modeling itself, and not from general systems considerations. Whether it exists other than in the eye of the beholder (perhaps, given Rosen´s emphasis on causes as answers to “why” questions, one should say “inquisitor”) is problematic. Traditionally, Aristotelean efficient causation has been associated with Modern mechanical causation, but Rosen specifically denies that living systems are mechanical. Traditional Aristotelean causes are always found in each instance of cause, and are not independent at all, as Rosen treats his causes, and as he must to separate the closure of efficient cause from other kinds of causation. His analogy to logical relations is not helpful, since they are not independent, as he claims they are. However, Rosen´s arguments that mechanical systems must be open to efficient cause are consistent with how he uses the notion of efficient cause in his graphs, and his extended argument that mechanical causation cannot be sufficient is sound, given the interpretation of his graphs. But his graphs alone do not imply general closure to efficient cause so much as suggest that it might be general for living systems. It is not clear whether Rosen draws his graphs to fit his notion of the living, or if he defines the living so as to fit his graphs. Autonomy does require some degree of self-modeling, and Rosen´s diagrams do suggest that the modeling is closed in living systems. Even if a system is predisposed to model itself as closed to efficient cause, however, it does not follow that this modeling reflects reality, or that it does not lead to problems of logical circularity concerning issues of origins, both temporal and representational, as I will describe shortly. Given past failures in terms of closed views of both life and mind, one has to be very careful. I see no grounds for thinking that Rosen´s view does not lead to the same problems that the viewpoint of Hussserl´s *Cartesian Meditations* present to Maturana and Varela, or, indeed, that his postulated condition of life is more clear than the non-mechanical postulates of vitalism.

At least Rosen does not have problems with infrastructure; metabolism and repair within organisms ground the closure of efficient causation in material causation, and we don´t have to worry about multiple instantiability, perhaps in Chinese populations on the other side of the world. Despite this, Rosen´s closure is complete, and does not permit the discrimination of degree and type allowed by autonomy. For this reason alone, I think autonomy is the preferable notion, quite side from logical and ontological problems, or the principled empirical problems that I will now discuss.

Maturana and Varela state: "Accordingly, an autopoietic organisation constitutes a closed domain of relations specified only with respect to the autopoietic organisation that these relations constitute, and, thus, it defines a ´space´ in which it can be realised as a concrete system; a space whose dimensions are the relations of production of the components that realize it." (Maturana/Varela 1980: 88). It should be obvious that this closure of autopoiesis ensures autonomy in any intuitive sense. But I am sceptical that there are any organisms in which the autopoietic organisation can be separated except in an ad hoc way from organisation involving heteropoietic interactions with the environment and other organisms.

The nature of process individuation and organisation requires a deeper analysis. Dividing a complex system into parts in order to explain how it functions, unless the processes make natural unities, is somewhat artificial, and leaves part of the explanation open. One important issue is origins. Imagine an artificially made bacterium. Our manufactured bacterium would have the same cohesion conditions as a natural one, and since the cohesion is the complex functional organisation that makes up autopoiesis in a natural cell (at least approximately), it would be just as autonomous as a natural cell. However, it would by definition be allopoietic (as manufactured), and its efficient cause would also be in the designer. Similarly, the efficient cause of a manufactured organism would be its creators. The autonomy notion avoids the paradox that isomorphic organisms could one be autonomous and the other not.

A second issue involves the existence of borderline and intermediate cases, such as slime mould and bacterial films. These colonies act like autonomous in many respects, involving signaling, differentiation and functional organisation. However, it is not clear whether they are best called colonies or individuals. Given such borderline cases do exist, it seems even more likely that they existed in transitions from the non-living to the living, and in the emergence of more complex living systems. The autonomy notion predicts the possibility of such difficult cases, but the absolute nature of autopoiesis and closure to efficient cause do not, and require that there be a clear-cut difference. The world is not so accommodating to our desire for sharp distinctions. We must accept an open notion of autonomy.

Definition of Autonomy

Assuming an open system approach, and that autonomy constitutes the dynamical identity of an organism, we can construct a concept of autonomy with the appropriate features. The basic ideas are from Collier (1988, 1999, 2000, 2004; Collier/Hooker 1999). The idea of autonomy can be defined, or, in line with the conceptual engineering idea, constructed, by starting with well-known philosophical notions, and then restricting these by adding further conditions until we arrive at a suitable definition.

1. Identity, A = B
a. Logical condition, same for all things
b. Equivalence relation: symmetric, transitive, closed

c. A = B implies that B has every property that A has, and vice versa

2. Unity, U(A)
a. Unity is the relation among the parts of a thing A such that:
b. If a and b are parts of A, then aUb, and bUa (symmetric)
c. If a and b are parts of A, then aUb and bUc implies aUb (transitive)
c. By a. and b., U is an equivalence relation
d. U(A) is the closure of U, given any initial part.
e. By a. to d., U(A) contains all and only the parts of A.

It is an empirical question what satisfies U(A) for a given A

3. Cohesion, C(A), dynamical unity
Cohesion is the unity relation for dynamical objects, such that:
a. All parts aCb are dynamical
b. C is dynamical

Simple examples of cohesion
a quartz crystal
the closure of intermolecular interactions gives the boundary of the crystal, external interactions being much weaker than internal interactions
a gas in a box
the cohesion of the box defines the boundaries of the gas.

Note that in each case the cohesion is not absolute; it is a matter of degree.
1. We should expect difficult intermediate cases.
2. Cohesion can differ in strength in different dimensions (factors)
3. We really need a *cohesion profile* to individuate an object
4. Cohesion both unifies a dynamical object, and distinguishes it from other dynamical objects.
5. Thus, it is quite effective as a criterion of individuation.
6. Its real strength, however, is in the way it forces us to look for dynamical closure whenever we want to claim that something is individuated.
7. Closure may be externally imposed, or else arise internally.
8. This is especially significant in the case of autonomy.

Autonomy is a special Type of Cohesion.

Cohesion is maintained actively though the contributions of component processes to the continued existence of the system, either directly, or through intermediate processes.

The requirements of autonomy place certain restrictions on what sort of organised system might be autonomous.
It should be obvious that neither a rock nor a gas in a box are autonomous, since they are not active in any sense.
To be active requires doing work. Doing work, in turn, requires the existence of non-equilibrium conditions – this means that there must be available resources to make use of. I cannot stress too much that autonomy is impossible unless there are sufficient resources available for use.
Neither a rock nor a gas in a box is autonomous because they cannot alter their own state to respond to processes that go across their boundaries. Thus they are unable to adapt to conditions around them, and certainly not to anticipate them.
In order to have this sort of self control, a system must be internally differentiated, that is, it cannot be in a uniform steady state, but must have a number of internal states that are dynamically accessible.
This requires a certain flexibility that systems whose cohesion is based in high energy differentials cannot maintain.
Thus we can expect it to be characteristic of autonomous systems that energy is not their primary concern, but rather organisation of their processes so as to divert energy as suitable for their survival.
It would be proper, then, to describe autonomous systems, and the degree of autonomy itself, in terms of relative organisation rather than in terms of relative energies of interactions.
This is coherent with the intuition behind autopoiesis that organisation is of central significance.
Furthermore, since processes contributing to autonomous cohesion must be coordinated so as to achieve viability, we should expect autonomous systems to show holistic organisation of a hierarchical sort in which open aspects of lower level processes are closed at higher levels. *The very identity conditions of the system embedded in its organisation active maintain and continue that organisation.*
However, unlike in autopoietic systems, this closure need never be complete. While internal *process closure* (sometimes called operational closure) is to some degree essential, there will also be *interactive closure* among processes, both within the internal infrastructure and with features of the external environment. This means that autonomy must be open to the outside.
We require only that the internal organisational closure is greater than the interactive closure. (Centripetal forces > centrifugal forces).
Comparing degrees of organisation is non-trivial.
In algorithmic complexity theory, logical depth, or the number of steps required to produce a surface structure from a deep structure, is often taken as a measure of

organisation. This value, though, is difficult to compute under the best of circumstances, and often impossible. (Atlan, sophistication)
Fortunately, differences in organisation are often large, and are correspondingly easy to recognise. Thus it is not impossible to pick out many autonomous systems, and even to compare their degree of autonomy, and further to compare autonomy in various respects. This is quite different from autopoiesis, which is an all or nothing, and quite indiscriminate condition (Varela 1979).

In summary, autonomy requires:
1) non-equilibrium conditions
2) internal dynamical differentiation
3) hierarchical and interactive process organisation
4) incomplete closure
5) openness to the world
6) openness to infrastructural inputs

The existence of autonomy, like any cohesion, is identical to the corresponding process closure, and is not something complementary to, or over and above, this closure. *In other words, the closure determines the self, and since it is active, we can call it self-organising.*

Some Properties of Autonomy
1. Levels and modules
these must be largely closed (cohesive), but must also be open in a sense, they must be dynamically penetrable to play a part in organisation.
2. Functionality
derives from contribution to self-preservation, or viability
3. Closure
Closure places severe restrictions on what can qualify as autonomous. This has consequences for determinations of functionality and partship

Implications for Explanation:
1. Explanations of parts must be open-ended
2. Complete explanations must not leave functional processes open
3. Explanations should be constructed or rendered so that modular and nesting connections can be made
4. Explanations in terms of organisation or energy and matter flows alone are incomplete; the two must correspond in every detail at the appropriate level

Implications for Research:
1. Closure suggests where to look to complete explanations

2. Required elements
3. Place of elements
4. Questions to ask functionally and materially

An Example: The Cheetah

A good example for the importance of organisation because
1. genetic variance is very low, so differences cannot be reduced to genes
2. viability envelope is small, so functional constraints are tight

Hierarchical organisation starts at the chemical level, and continues up through physiology and organs, condensing in the cheetah, and then branching out into environmental factors.

The intersection of the genetic and ecological hierarchies in the individual cheetah means that the organism plays a dual role, ecological and genetic. The two roles are not the same, nor are their closure conditions. This account focuses on the ecological.

Chemical level:
Example, respiration
fermentation and oxidative phosphoralysation (Krebs) cycles.

Consider fermentation, over which there was a long debate as to whether it was a biological or purely chemical phenomenon. As it turns out, fermentation is possible outside cells, but it is not maintained for long.
The first chemical models assumed a simple linear process; later more complex linear models were tried. It eventually turned out that the chemical process required early elements later in the process, making it non-linear.
This means that there is feedback in the process, in which at least some elements (or types in this case, if we assume molecules rather than a fluid) cycle in a closed way. In fermentation in the muscle, glucose is the input, and lactic acid the output.
If the process is laid out linearly, there are two places where ADP enters and ATP leaves, one place where ATP enters and ADP leaves, and one place each where nicotinamide andenine (NAD) leaves and NAD+ enters and the contrary.
Closing these open loops at the ends requires that products of the process are needed earlier as inputs. This makes the process indecomposable.
It should be noted, though, that we can see quite clearly what is going on at each stage as well as throughout the process, so even though the process itself is not reducible to its component stages, the stages are still an important part of the explanation.

Note also that an extra ATP molecule is formed, which is used by the muscle for energy, and reduced to ADP, increasing the scope of the cycle.
The history of respiration and oxidative phosphoralysation is similar, with the final model the familiar Krebs cycle, which both has cyclic properties like fermentation and also shows similar connections to other processes. The main difference is that fermentation builds up lactic acid, which cannot be removed from the cells quickly enough, and eventually reduces the efficiency of the process. The Krebs cycle is less efficient in producing power, but it uses oxygen, and produces easily removable carbon dioxide and water as waste products.

Implications for the Cellular Level and Above:

A process is closed if and only if it requires no inputs or outputs at the level at which it is defined. Clearly, fermentation and respiration are not closed, since they require an input of glucose directly into the process itself, at the same level as the process occurs, despite the loops in the process. This requires control of cellular mechanisms to improve transport, but it also requires control of other organs and behaviour. Even at the chemical level, enzymes facilitate the process, with 10 aiding glycolysis alone. This is possible only in a cellular environment.

The excess ATP is used for energy, in muscle cells for contraction.
In the Cheetah, which requires high speeds for chases, the fermentation stage allows these speeds for short times.
After lactic acid builds up, the system switches over to the Kerbs cycle, which does not allow such high muscle activity.

This has implications for the cheetah´s behaviour:
It requires a relatively short chase to be likely to be successful.
Thus, it slowly stalks its prey, and then attacks quickly from a close distance.
It also prefers more vulnerable prey, which will require less expenditure of energy.

There are also related adaptations, such as the colouration, including spots, that make the cheetah less visible as it is stalking its prey.
Further adaptations involve the training of cubs with increasingly difficult prey, and eventual cooperation with the mother in stalking and attacking prey. This learning process allows adaptation to local conditions at the behavioural level.

The interactive closure with the environment allows much more flexibility for different conditions of local vegetation and prey. Cheetahs are successful in roughly 50% of their attacks, which is close to the level required for their survival, so these adaptations are especially important.

Interestingly, the training of cubs must be carried out well within the viability envelope of the cheetah. To close to the edges, and the cubs would not survive. The adult cheetah typically lives much closer to the edges of its niche much of the time.

Physiological Level:
A second consideration is that the fermentation and Krebs cycles require inputs of sugar and oxygen and removal of waste.
This is done through transfer through the cell walls, and transportation from the gut and to the lungs.
A large efficient heart aids this process.
When oxygen is required efficient lungs are helpful, and the ability to achieve high heart rates is essential.
The molecular processes are hardly closed processes, but are coordinated and integrated with other organs and behavioural processes.

Central control, the nervous system:
Much of the control of the cheetah´s behaviour, both autonomic and intentional, is governed by the nervous system.
Although nerves do not reproduce in an adult animal, they continually change their connections and levels of neurotransmitters at synapses.
Even the basic structure of the nervous system and its relation to behaviour is far more complex than might be expected.

Neural, genetic, behavioural process closures
Schaffner (1998) uses the example of C. elegans, a nematode whose genetics, muscular and neural structure are almost completely known. He notes, for example, that whereas there are some cases in which one gene affects one neural connection, which affects one part of behavior (not a very useful one in itself), in most cases there are many-many relations among genes, neural connections and behavior, suggesting more complex cyclic functions. In fact, some of these more complex neural networks and gene-neural network relations have been worked out, confirming the non-linear nature of the processes. Furthermore, networks of neural networks are involved in some behaviors, and can produce variant behaviors depending on external stimuli, introducing even more complexity and feedback. From the perspective of an individual C. elegans, some processes are linear from DNA to behavior, whereas others involve internal closure, while for others the closure includes environmental interactions.
It is worth noting here that the reproduction-selection feedback cycle allows even the linear processes to contribute to maintenance in a cyclic way at the lineage level. In other words, closure is achieved for the process not in the organism, but in its lineage.

In higher animals like cheetahs, we can expect more complex many-many relations among neural connections and behaviour, as well as to genes.
The complex behaviour required in a chase requires considerable flexibility.
Although these actions are largely reflexive (thinking them out would take too long), the fact that cubs must learn how to chase and kill prey indicates that this behaviour is not programmed in the genes, but rather involves a complex organisational relation among genes, nervous system and environmental interaction.
This organisation is essential to the survival of the cheetah and its lineage.

References:

Collier, John (1988) *Supervenience and Reduction in Biological Hierarchies*. In: Biology and Philosophy, Canadian Journal of Philosophy, Supplementary Volume *14*, edited by M. Matthen and B. Linsky (Calgary: University of Calgary Press). http://www.kli.ac.at/theorylab/jdc/papers/redsup.pdf

Collier, John (1999) *Autonomy in Anticipatory Systems: Significance for Functionality, Intentionality and Meaning.* In: Dubois, Daniel M. (Ed.) (1999) *Proceedings of CASYS´98, The Second International Conference on Computing Anticipatory Systems*. New York. Springer. http://www.kli.ac.at/theorylab/jdc/papers/casys98.pdf

Collier, John (2000) *Autonomy and Process Closure as the Basis for Functionality*. In: Chandler, Jerry L.R./Vijver, Gertrudis van de (Eds.) (2000) *Organisations and their Dynamics*, Volume 901of the *Annals of the New York Academy of Science*: 280-291, http://www.kli.ac.at/theorylab/jdc/papers/closure.pdf

Collier, John (forthcoming 2004) *Self-organisation, Individuation and Identity.* In: Revue Internationale de Philosophie.

Collier, John/Hooker, C.A. (1999) *Complexly Organised Dynamical Systems.* In: Open Systems and Information Dynamics, 6: 241-302, http://www.newcastle.edu.au/centre/casrg/publications/Cods.pdf

Maturana, Humberto R. (1988) *Reality: the Search for Objectivity Or the Quest for A Compelling Argument*. In: The Irish Journal of Psychology: 25-82.

Maturana, Humberto R./Varela, Francisco J. (1980) *Autopoeisis and Cognition.* Dordrecht. Reidel.

Maturana, Humberto R./Varela, Francisco J. (1992) *The Tree of Knowledge: The Biological Roots of Human Understanding*. Boston. Shambhala.

Millikan, R.G. (1989) *In Defense of Proper Function*s. In: Philosophy of Science 56, 288-302.

Neander, K. (1991) *Functions As Selected Effects: The Conceptual Analyst´s Defense*. In: Philosophy of Science, 58 168-184.

Rosen, R. (1991) *Life Itself*. New York. Columbia University Press.

Varela, F.J. (1979) *The Principles of Biological Autonomy*. New York. North Holland.

Varela, F.J (1996a) *The Specious Present: A Neurophenomenology of Time Consciousness*. In: Petitot, Jean/Varela, Francisco J. (Eds.) (1996) *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science.* Stanford. Stanford University Press, Chapter 9, pp.266-329.

Varela, F.J (1996b). *Neurophenomenology : A Methodological Remedy for the Hard Problem*. In: Journal of Consciousness Studies, J.Shear (Ed.) Special Issues on the Hard Problems.

Varela, F. J./Thompson, E./Rosch, E. (1991) *The Embodied Mind: Cognitive Science and Human Experience.* Cambridge, MA. MIT Press.

II.4. Social Systems

The Autocreation of Communication and the Re-creation of Actions in Social Systems

Christian Fuchs and Gottfried Stockinger

We look at a creative social process from two angles: from the point of view of communication and from the point of view of social action. From the perspective of communication, social self-organisation denotes the permanent creation of reality through concatenation of communication units in a self-referential mode (auto-creativity). From the perspective of the individual actor, social self-organisation denotes a permanent interaction process related and coupled to the communication structures (re-creativity). Depending on which level of analysis one focuses, one can either stress communicative self-referentiality (e.g. Niklas Luhmann) or the interrelations of actors (e.g. Anthony Giddens and Pierre Bourdieu).

For the purpose of explaining the whole process of social creativity, we try to unify the different approaches, as if they were part of a major collective and co-operating intelligence.
The main argument is that the creativity of social systems is based on autopoietic or self-reproducing processes on both the level of communications and the level of actors and that on both levels creativity is an important feature.

Trying a dialectic synthesis between these two major approaches, we look at auto-creativity as dialectically (that means: in terms of complementary opposites) coupled to individual re-creative action processes. Vice versa, we look at re-creativity as based on auto-creative relationships of actors. In order to co-ordinate their interactions, actors self-produce in a social process and use symbols in communicative processes. The notion of communication covers a social reality of its own, where individual action is a necessary condition, but can´t be reduced to the individuals. Communication takes place, wherever and however two or more actors are related practically.

Communication is based on action, social action is based on communication. In social reality, we find that the evolution of society is based on communicative action. Jürgen Habermas defined communicative action as referring "to the interaction of at least two subjects capable of speech and action who establish interpersonal relations (whether by verbal or extra-verbal means). The actors seek to reach an understanding about the action situation and their plans of action in order to coordinate their actions by way of agreement. The central concept of *interpretation* refers in the first instance to negotiating definitions of the situation which admit of consensus“ (Habermas 1984: 86). In communicative action, actors try to co-ordinate plans of action and to achieve mutual understanding by their symbolic interactions. The personal encounter can also be an indirect one, e.g. mediated by communication technologies such as letter, telephone or a computer network. Therefore, communicative action is based on direct or indirect personal encounter mediated by a shared symbolic system. In order to achieve a common understanding, certain claims to validity must be fulfilled (comprehensibility, truth, truthfulness, rightness). The technological mediation of communication certainly makes such a fulfillment more difficult, but not impossible.

As shown in figure 1, global social structures result from the practical communicative relationships of actors and subsystems and these structures enable the permanent reproduction process of communications and actions. In this paper we discuss how structures are coupled with communications on the one hand and with actions on the other hand. By "deconstructing" the real world processes into two analytical levels, we show that both the action and the communication level have their internal "autopoiesis"[1]. In figure 1 we use two spirals instead of arrows in order to show that the relationships between communicative actions and global structures can be characterised by non-linearity, complexity and emergence. Due to the creativity of social systems, these systems are always non-linear and there is a certain degree of contingency in their behaviour.

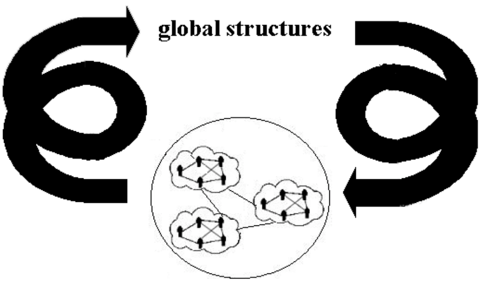

Fig. 1.: The self-reproduction of communicative action systems

[1] We use the term „autopoiesis“ in a metaphorical sense. Autopoiesis refers to the biological self-organisation of living systems. Social systems are more than just autopoietically self-reproducing, they are auto-creative and re-creative.

1. The Quality of Communication: The Auto-Creativity of Social Communication Systems

We argue, that the difference of the social information process, which distinguishes it namely from the biotic one, refers particularly to the capabilities of human communication and social relationships, like productivity, mutuality and creativity. In their combination, these capabilities allow higher degrees of freedom in the self-organisation of social systems, resulting in processes of social variation and selection. In society, communication goes beyond the mechanic and biotic information processes. While physical and biotic systems evolve in a given environment, social systems, based on signs and symbols, evolve to a point where they are able to create their environment themselves. The dialectic opposition between society and nature gets a new perspective in communicative environments, where the socio-ecological structures are maintained by expectations which point to the future. Communication takes places as a collective effort to compensate the uncertainty of the social process to which the individuals are exposed. In this effort, endless circuits of reflection give the social information process degrees of freedom not limited by a given environment, but self-sustained.

Based on their capacity to operate virtual information (symbols, ideas), social systems develop a variety of subsystems not produced by nature. This gives way to a new quality of interaction: communication (see Stockinger 1998, 2001). Through communication social systems are able to deal with all kinds of elementary, intermediary and systemic capabilities of the psychic systems coupled to them, like reflectivity, adaptability and creativity. They allow to differentiate and combine these faculties at the collective level, which makes them able to change their forms and contents of expectations almost immediately. Therefore, mechanical and technical information models, which work with metaphors like ”information exchange, emission and reception“, may not be applied to social systems. At the stage of social interaction, they reveal themselves insufficient to explain social complexity, variety and mutability. At the basic levels, signals are processed in form of orders or commands, and emitters and receptors do not pass trivial stages, even if their information is assumed to be disturbed by the noise of a channel (Shannon/Weaver 1949). At the biological level, the channel is part of the environment, and mutations occur by coincidence, guiding the autopoietic process. In distinction, the social system´s autopoiesis and re-creativity does not depend on external conditions of a given social environment. It is auto-creative. Social systems do not only create themselves but also their own environment. Even their physical and biological environment is processed in form of a social code of signs, symbols and signals. Immerged in a social environment, totally produced by it, social systems (communication + action systems) process their world in terms of sense and meaning which is not repeatedly the same, but changes when creativity is required.

By auto-creation the “autopoiesis” of a communication system is realised and self-referential production circles of communication emerge which are mediated by global structures (see fig. 2). “Social systems use communications as their particular mode of autopoietic reproduction. Their elements are communication which are recursively produced and reproduced by a network of communications and which cannot exist outside such a network” (Luhmann 1988: 174).

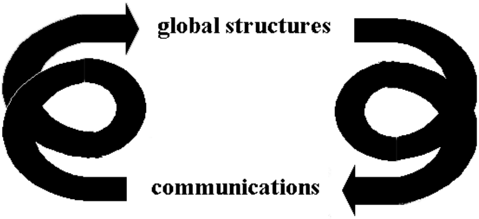

Fig. 2: The auto-creation of communication systems

Social structures are based on communication circuits, whose stability is permanently challenged by the principle of “order from noise”, where noise is “internally” produced (“improbability of communication”, selection of information, message and comprehension) or comes from “outside”, from interactions of individuals. This affects social comprehension through a “shared symbolic system” (culture, Talcott Parsons): under conditions of social creativity (structural change) in communication society, the participants lack direct access to each ones ”world“, as it was the case in traditional society. This is a logic result of a secular megatrend called “individuation”. Identity is not only the difference to the other one, but is based on the difference between Identity and Difference. A next-order observation-level shows up.

At this level, the relation to the other, is already a mediated one. It is open. It is neither completely determined, nor completely indetermined. There is a possible “Butterfly-effect” between cause and effect. Actio non est reactio. That´s why the human being is able to change his views hence social information relationships result in a faster differentiation, leading to constructive reflection (konstruktive Widerspiegelung). A new quality shows up: we call it *self-creation*. It is based on interaction, communication and expectations. Due to the constant possibility that expectation will not be fulfilled, additional abilities to deal with an uncertain future develop: collective intelligence and co-operation. Co-operation requires action, and a whole action theory is available, as we will show later. Communications stays in the realm of collective intelligence. It is the base, but not the result, of intelligent co-operation.

As Stockinger/Fenzl (1992) pointed out, collective intelligence only profits, when certain conditions are fulfilled: the basic ones are peace (construction, not destruction), truth (non-alienation), love (cohesion) and news (information). These conditions lead to freedom (out of necessity, Marx), and to individuals responsible for the conscious production of their lives. The practical use of almost infinite degrees of freedom is only possible when self-organisation, based on interactivity and mutuality, and not heteropoiesis, based on command and imposition, is the hegemonic form of regulation. The increasing capacity of interactive communication and information processing produces the destabilisation of human life worlds, exposing them to social uncertainty. While industrial society was still comparable to an organic being, communication enhances the potential of the social information process at the micro social level. That means that the potential ability of communication to allow the social units practically unlimited degrees of freedom, only bound by self-control of omnipresent humanity, increases as they do not depend any more on given or prefabricated social environments. As long as the social information process was repressed by traditional and commendatory structures, this was not the case. When de-repression and democratisation unfolded worldwide in the last decades, new degrees of social mutuality were added, and communication began to reveal itself as the social system´s capacity to produce its own environment. Only nowadays this overall reflexive process created and used by humans, results in the foundations for the conscious production of their lives. There are no more sectors of human life left, where communication would not lead or influence social actions. Luhmann argues that "the theory of selfproducing, autopoietic systems can only be transferred into the range of action systems, if one assumes that the elements, of which the system consists, exist only temporarily and therefore have to be reproduced again and again by the elements of the system itself" (Luhmann 1984: 28).

Therefore, we observe a double meaning of the social process. From the point of view of the communication systems, with their own subjectivity (self-reference), individual actions are not subjective but objective data in the sense of a "conditio sine qua non". They rely on individual action whose subjectivity as cognitive systems is built up on information as a difference that makes a difference. Usually, such differences emerge as unexpected, almost casual factors. Therefore, information has a certain degree of uncertainty for the observing actor. This uncertainty enters the communication process as objective information (data flow, noise patterns).

The objective aspect of information (for individuals) lies in the fact that social relationships reflect their acts in reference to the output of the communication system. When actors communicate, information "catalyses" an objective relationship between them because of the involved co-reflection of the communication level. Because of this dialectic relation between action and communication, this reflection (Widerspiegelung) is not a mechanical reproduction of data by a receiver. Communication is therefore not a linear mutual reaction of one communication partner to the symbolic actions of the other partner. They react reflexively, mediated by the communication system. For the actors, the result of these selections, which leads inevitably to action (or to the collapse of the system, if no communicative action follows), appears as objective information.

The information effect of actions, when coupled to a communication system, is subject to an emergent synthesis of three selections (selection of information, uttering and understanding). Its because of the mediation by communication (with its own selections) that the actions are not determined exactly. They are "free" in the sense that they are, to a certain extent, not predictable by and reduceable to the dominating structures, regularities and redundant actions that can be found in the social world. Such reflective reactions are neither completely determined, nor completely undetermined, Luhmann calls this "contingency". Their causality can be characterised as relative chance and incomplete determinism. Although objective information (secured by a communication structure) reproduces milliards of times per day relatively stable, a small deviation may lead, in certain critical situations (which occur quite frequent nowadays) to a very improbable state (Butterfly effect).

The degrees of uncertainty are due to different degrees of recognition and legitimisation of norms, values, cultural contexts, interpretative schemes, tastes and life-styles. The degree of freedom depends on the revolution of structures of durable and institutionalised behaviour which inhibit creative, deviant, subjective behaviour. On the other hand, communication structures store and fix social knowledge and hence they simplify the orientation of social actions. This may be seen, by an actor who looks for certainty, as a positive quality. But structures can turn out to be counterproductive, when it comes to the question of social change. In phases of quickly changing information, when differences arise massively, the multiple information relationships we enter daily affect the individuals´ knowledge and other experiences. When institutionalised structure orientation is missed or dismissed, the human being is able to change his views hence social information relationships result in a faster differentiation, leading to constructive reflection (konstruktive Widerspiegelung). This reflection involves communication where different alternative interpretations and behaviours are possible. It depends on the degree of participation of the actors and of the democratisation of the communication system to which extent interpretation and critical reflection are activated.

2. The Quality of Actions: The Re-Creativity of Social Action Systems

Social structures don´t exist externally to agency, but only in and through agency, in mutual penetration. Agency means the field of real interaction. By social interaction, new qualities and structures emerge, even if they are not perceptible at their initial stages. They cannot be reduced to the individual level, but they may be attributed to them by the auto-creative communication level. The process of bottom-up emergence is called agency, invention or creation. Emergence in this context means the appearance of at least one new systemic quality that can not be reduced to the elements of the communication system to which the action is coupled. So this quality is irreducible and it is also to a certain extent unpredictable, i.e. time, form and result of the process of emergence cannot be fully forecasted by taking a look at the elements, their history and their actual interactions. Social structures are coupled to and influence actions and thinking, although not linearly. They constrain and enable the practice of social actors, "guiding" them in this way. This is a process of top-down emergence where new properties of actors and groups can emerge. The bottom-up- and the top-down-process together form a cycle that permanently results in emergence on the level of structures and the level of actors. This whole cycle is the basic process of systemic social self-organisation that can also be called re-creation (see fig. 3)[2]. By permanent recurrence to processes of agency, constrained/enabled actions co-evolve within a social system, which therefore can maintain and reproduce itself. Like communication, agency again and again creates its own unity and maintains

[2] Humans have the ability for self-reflection (Jantsch 1979: 111, 229f). This results in the ability of anticipation which makes the active, creative design of the future possible. Self-reflexive systems can map the outer world onto thoughts, ideas and plans which enables them to manipulate their environment. Jantsch considers social systems also as re-creative ones because they can create new reality (Jantsch 1979: 305), the socio-cultural human being has the ability to create the conditions for his further evolution all by himself (343). The self-reflection that is characteristic for humans means to Jantsch also that they can and must take responsibility for the world they live in.

itself. Social structures enable and constrain the practice of social actors and are a result of social actions.

Society reproduces human actors as social beings and human actors produce society by socially co-ordinating human actions. Man is creator and created result of society, structures and human actors produce each other mutually. Such a conception of social self-organisation acknowledges the importance of the human being and its actions in social systems. Saying that man is creator and created result of society corresponds to Anthony Giddens´ formulation that in and through their activities agents reproduce the conditions that make these activities possible (Giddens 1984: 2).

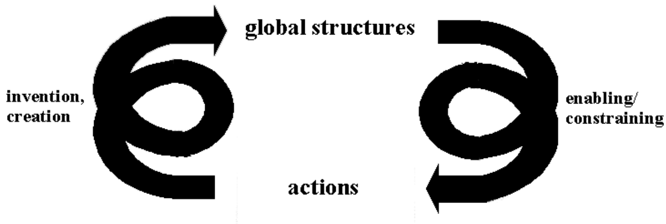

Fig. 3.: The re-creation of social systems

Re-creation denotes that actions, as moments of a social system, permanently change their communicative environment. This enables the social system, as a necessary condition for it, to change, maintain, adapt and reproduce itself. The term re-creation refers to the ability of humans to consciously try to shape and create social systems and structures, an ability that is based on self-consciousness and the reflexive monitoring of action. Social action systems are re-creative ones because they can create new reality, not from zero, but by changing the old one. The socio-cultural human being has the ability to create the conditions for his further evolution all by himself. Creativity means the ability to spontaneously, gradually or revolutionary change actual settings, creating something new that seems desirable and helps to achieve defined goals. It is not an isolated human quality, but linked to the co-evolution of other human social qualities.

The human being is a social (= communicatively interacting), self-conscious (= it has awareness of its own), creative (= not repeating), reflective (= self-referenced), cultural (= it depends on media), symbols- and language-using, active natural, labouring, producing, rationally abstracting, objective, corporeal, living, real, sensuous (= sense producing and processing), anticipating (= based on expectations), visionary, imaginative (= capable to deal with virtual reality), expecting, designing, co-operative, wishful, hopeful being that makes its own history, with chances to strive towards freedom and autonomy (for details see Fuchs 2002c, d). It can also be the case that it doesn´t make use of its possibilities and strives towards competition and co-destruction.

The human being can create images of the future and actively strive to make these images become social reality. Within a collective intelligence of mankind, individuals can anticipate possible future states of the world, society as it could be or as one would like it to become; and they can act according to these anticipations. Each one has its ideals, visions, dreams, hopes and expectations which are based on the ability of imagination which helps the individual to go beyond existing society and to create alternatives for future actions. Based on creativity, individual or social entities design a society. This creation, as a human activity, goes beyond facticity, creates visions of a desirable future and looks for a solution to existing problems.

Design creates new knowledge and findings. Man designs machines, tools, theories, social systems, physical entities, nature, organisations etc. within social processes. Such an understanding of design as a fundamental human capability takes into account man´s ability to have visions and utopias and to actively shape society according to these anticipated (possible) states of the world.

Terming the self-organisation of society re-creation (of action systems) acknowledges as outlined by Giddens the importance of the human being as a reasonable and knowledgeable actor in social theory (for a discussion of the relationship between structuration theory and social self-organisation see Fuchs 2002a, Fuchs 2003a). Giddens himself has stressed that the duality of structure has to do with re-creation: "Human social activities, like some self-reproducing items in nature, are recursive. That is to say, they are not brought into being by social actors but continually *recreated* by them via the very means whereby they express themselves as actors" (Giddens 1984: 2).

Saying that society is a re-creative or self-organising action system means that the structural properties of social systems are both medium and outcome of the practices they recursively organise and both enable and constrain actions. Structuration theory holds that the structures drawn upon in the production and reproduction of social action are at the same time the means of system reproduction (Giddens 1984: 19). In this respect, human social activities are recursive because they are continually recreated by the actors whereby the latter express themselves as actors.

Social structures don´t exist outside of and are based on actions, they are "rules and resources, or sets of transformation relations, organised as properties of social systems" (Giddens 1984: 25). In and through their activities agents reproduce the conditions that make these activities possible (ibid.: 2). "According to the notion of the duality of structure, the structural properties of social systems are both medium and outcome of the practices they recursively organise" (ibid.: 25) and they both enable and constrain actions (ibid.: 26). Social systems and their reproduction involve conscious, creative, intentional, planned activities as well as unconscious, unintentional and unplanned consequences of activities. Both together are aspects, conditions as well as outcomes of the overall re-creation/self-reproduction of social systems.

The mutual relationship of actions and structures is mediated by the habitus, a category that describes the totality of behaviour and thoughts of a social group. The habitus is neither a pure objective, nor a pure subjective structure. The habitus means *invention* (Bourdieu 1977: 95, 1990b: 55). In society, creativity and invention always have to do with relative chance and incomplete determinism. Social practices, interactions and relationships are very complex. The complex group behaviour of human beings is another reason why there is a degree of uncertainty of human behaviour (Bourdieu 1977: 9, 1990a: 8). Habitus *both* enables the creativity of actors and constrains ways of acting. The habitus gives orientations and limits (Bourdieu 1977: 95), it neither results in unpredictable novelty nor in a simple mechanical reproduction of initial conditionings (ibid.: 95). The habitus provides conditioned and conditional freedom (ibid.: 95), i.e. it is a condition for freedom, but it also conditions and limits full freedom of action. This is equal to saying that structures are medium and outcome of social actions. Very much like Giddens, Pierre Bourdieu suggests a mutual relationship of structures and actions as the core feature of social systems (for a discussion of the relationships between Bourdieu´s theory and social self-organisation see Fuchs 2002b). The habitus is a property "for which and through which there is a social world" (Bourdieu 1990b: 140). This formulation is similar to saying that habitus is medium and outcome of the social world. The habitus has to do with social practices, it not only constrains practices, it is also a result of the creative relationships of human beings. This means that the habitus is both opus operatum (result of practices) and modus operandi (mode of practices) (Bourdieu 1977: 18, 72ff; 1990b: 52). The concept of the habitus reflects the importance of incomplete determinism and relative chance in social systems. There are certain degrees of freedom of action and communication, social relationships are always non-linear, complex and result in emergent properties.

In society one can find more global and more local levels, global structures are e.g. state laws, a nation state, the property structure, capital, global networks and institutions etc. One more local levels one will find certain subsystems (economy, politics, culture, media, family, education, art etc.), social organisations and finally individual actors. There might be stability and coherence on a higher level for a long time, but this stability can only be maintained by dynamics and the permanent emergence of new qualities on lower levels. In phases of stability, order on a higher level results from permanent change on a lower level. There is a permanent flux and movement in society. As Pierre Bourdieu has shown, this has to do with social and symbolic struggles.

From time to time, a social systems enters crisis and phases of instability due to social antagonisms. The auto-creation and re-creation of social systems takes place permanently. This is a very general level of analysis. Phases of stabile auto- and re-creation result in phases of instability where the future development of the system is highly undetermined. The objective structures condition a field of possibilities, it is not pre-determined which alternative will be taken. In such phases of crisis and bifurcation, agency and human intervention play an important role in order to increase the possibility that a certain desirable alternative will be taken. Certainty can´t be achieved, but agency also is not made impossible by the principles of self-organised social change. The whole movement of social self-organisation is based on a dialectic of chance and necessity.

Ascending from the abstract to the concrete there are three levels of social analysis: 1. society in general, 2. the social formation, 3. modes of development (see Fuchs 2002d, e). On the first level, society is considered as an auto-creative and re-creative system, i.e. global structures and communicative actions are producing each other mutually and develop in space-time. A social formation is a concrete historical and societal epoch that is characterised by a concrete expression of social structures and relationships that remain cohesive from beginning till the end of the formation although they change dynamically on a still more concrete level. There is homogeneity within diversity of social structures and relationships of a formation of society. A formation of society is itself a sequence of different phases. Such phases are our third level of analysis and are also called modes of development, a term which describes a temporal coherent unity of economic, political and cultural aspects within a social formation.
Auto-creation and re-creation take place permanently in all social systems and societies. These processes can be described on level one of social analysis. A phase of instability can result in the reproduction of a social formation, i.e. a new mode of development within the old social formation or a new social formation. Phases

of instability and more concrete social analysis are aspects of the levels two and three.

There are two types of re- and auto-creation: the integrative, reproductive one and the disintegrative, discontinuous ones (see Bourdieu 1986: 165). They don´t exist independently because it is determined that each social formation and mode of development enters a phase of instability, but it is uncertain when this will be the case, what the exact reason and the outcome will be. We both find continuity and discontinuity in society. Social systems are historical systems (Wallerstein 1974), they have a beginning and an end, as well as auto- and re-creative dynamics in-between.

3. Conclusion: Communication, Social Action and the Role of Co-operative Intelligence

We look at co-operation as a collective process that makes use of the auto-creativity and re-creativity of social systems in order to achieve defined goals more efficiently. Schmidt/Bannon (1992) argue that mutual dependence is a condition for co-operation: "people engage in co-operative work when they are mutually dependent in their work and therefore are required to co-operate in order to get the work done. [...] Being mutually dependent in work means that A relies positively on the quality and timelines of B´s work and vice versa" (Schmidt/Bannon 1992: 13). We argue that interdependence may be a necessary condition, but it is not sufficient for co-operation to emerge. Because even if some tasks might be reached individually, actors engage in co-operative relationships because they can achieve goals more efficiently and more quickly together with others who share similar assumptions and goals. Co-operation can be accomplished across spatial and temporal distances because modern technologies enable the disembedding and reembedding of social relationships. Co-operation involves mutual learning and mutual aid. Co-operation means social situations and processes where human actors co-ordinate their actions and communications in such a way that the social system makes use of its auto- and re-creativity and creates a new reality that represents a shared goal (see also Oberquelle 1991[3]).

Co-operation means that actors communicatively make concerted use of existing rules and resources in order to create new rules and resources (cf. Fuchs 2003b for

[3] "Unter kooperativer Arbeit sollen Arbeitssituationen verstanden werden, in denen mehrere Personen zusammenarbeiten zwecks Erreichung eines Ergebnisses, welches unter den gegebenen Randbedingungen nur gemeinsam, aber nicht einzeln erzielt werden kann".

a more detailed discussion of co-operation in complex systems). Rules and resources (structures) are medium and outcome of co-operation in communicative settings with positive "symbiotic" relationships. We call them intelligent relationships, they are based on *collective intelligence* or *wisdom* which describes social situations, processes and states where there is a participatory constitution, design and usage of rules and resources and which are considered fair, just and fulfilling by the involved actors, within the framework of individual participation.

A system and its design can be considered as *participatory* if actions are based on learning: the users´ experiences, values, ideas, wishes and visions are reflected not only individually, but in relation to a communication system in which intelligent actions are elementary. Users are enabled to understand the system and create their role in the system, if the design principles of the coupled communication system aims at creating consensual context among them. Such a design ensures that people will take part more effectively and at a deeper level of commitment in the design process and systemic evolution (see Banathy 1996, Ackoff 1981)

Collective intelligence means the communicative problem solution capacity of social systems and involves self-development and self-determination. "Collective intelligence is a form of universal distributed intelligence, constantly enhanced, co-ordinated in real time, and resulting in the effective mobilisation of skills" (Lévy 1997: 13). In collective intelligence there´s mutual recognition and enrichment of individuals, skills are effectively mobilised (ibid.: 14ff). CI is constantly enhanced an co-ordinated in real time, individual acts are co-ordinated and evaluated in real time, according to a large number of criteria that are themselves constantly re-evaluated in context (ibid.: 17). In CI there is a collective vision and awareness of how different communication and actions are integrated (ibid.: 16). The actors of a CI are unique and in a permanent metamorphosis, they are nomadic. CI has to do with norms, values and the selection of alternative communications and actions. Computers are mechanistically operating machines, they have almost no degrees of freedom in their programmed behaviour, hence there is no *artificial* CI, only communicative and human CI.

Actors have certain goals and there are different ways of reaching them. Combining certain ways might be symbiotic in such a way that the goals don´t interfere and by co-operation all participating actors can benefit from each other and reach their goals. A social "symbiosis" is a communicative setting where all actors benefit and no-one loses and a positive, intelligent whole emerges by co-operation. By co-operation collective intelligence is reached, hence one can also speak of *co-operative intelligence*. Social systems are problem-solving systems. In order to do so, they are auto- and re-creative, they create new reality and new environments. These systemic capabilities can be designed in different ways, co-operation is one of them. By communicating and co-operating, desirable social settings and mutual benefits can be reached.

New media allow information to be distributed worldwide as an abundant and therefore almost free good (Stockinger 2001). The problem does not lie any more in the possession or the exchange of information, but in the production of socially significant sense, processed in communication, worldwide and instantly. The restoring of feeling present, produced by the use of interactive media plus the advantage of mass-communication gives the social environment a new quality: mass interactivity. The new dimension reveals how society is constructed virtually by distributed communications, which can lead to the autopoiesis of communities of participants. In such communities there is a participatory, co-operative production and usage of rules and resources. A participatory and co-operative usage of new media within participatory, co-operative social settings can enrich communication and foster collective intelligence in co-evolution with intelligent co-operation.

There are different forms of communication, action and designing society. There are also different ways of co-operating. Participatory co-operation can be Intelligent Co-operation so that all involved communication partners have advantages and can benefit. Intelligent co-operation is a way of creating new reality in auto- and re-creative loops. Auto- and re-creation processes result in new global structures. The relationships between these structures and communicative actions are non-linear and complex ones which result in emergent properties on both sides. By intelligent co-operation structures can emerge that enable a participatory and sustainable design of society and social systems. If this is the case, one can speak of the emergence of Co-operative Intelligence. Fig. 4. illustrates the emergence of Co-Operative Intelligence and Intelligent Co-Operation in auto- and re-creative loops where social actions and communications are co-ordinated intelligently so that a new intelligent whole emerges that enables a participatory and sustainable design by acting and communicating. Table 1 shows the similarities and differences between the concepts of Collective Intelligence and Intelligent Co-operation/Co-operative Intelligence.

Fig. 4.: Intelligent Co-operation/Co-operative Intelligence

A comparison shows that collective intelligence is related to the communication quality of a social system, while intelligent co-operation refers to the quality of social actions:

COLLECTIVE INTELLIGENCE (P. Lévy) Communication quality	**INTELLIGENT CO-OPERATION, CO-OPERATIVE INTELLIGENCE** (Stockinger/Fuchs) Action quality
A form of universal distributed intelligence, constantly enhanced, co-ordinated in real time, and resulting in the effective mobilisation of skills	A form of global co-operation, based on intelligent actions enhanced by communicaton and resulting in the effective application of mobilised qualities
mutual recognition and enrichment of individuals rather than the cult of fetishized or hypostasized communities	Recognition and enrichment of individuals and their communicative environments, neither fetishized nor hypostasized
Intelligence is constantly enhanced.	Co-operation is constantly enhanced,

Constantly better in getting better	getting constantly better in getting better. The coupled intelligence "learns"
Intelligence is co-ordinated in real time	Co-operation co-ordinates intelligent actions
Skills are effectively mobilised	The whole set of skills as a quality of a social system is effectively mobilised
Collective intelligence must not be confused with totalitarian projects involving the subordination of individuals to transcendent and fetishistic communities	Totalitarian projects may not be confused with intelligent co-operation, as co-operative intelligence is distributed and therefore, by "nature" contrary to any type of involuntarily subordination.
Education based knowledge is a necessary condition for collective intelligence to emerge.	Education is not necessary, but wishful. Even if individuals might be stupid, their action can result in an emergent behaviour that is globally intelligent and enhances their individual skills and abilities.
Individual acts are co-ordinated and evaluated in real time, according to a large number of criteria that are themselves constantly re-evaluated in context.	Social actions realised by individuals in the name of a co-operative (das Kooperativ), are evaluated according to one criteria: do they or do they not avoid social conflict. By avoiding conflict, there is a chance of co-operation to emerge.
We pass from the Cartesian cogito to cogitamus.	We pass from cogitamos to co-agitamos

Tab. 1.: Similarities and differences between the concepts of Collective Intelligence and Intelligent Co-operation/Co-operative Intelligence

References:

Ackoff, Russell L. (1981) *Creating the Corporate Future.* New York. Wiley.

Banathy, Bela H.(1996) *Designing Social Systems in a Changing World*. New York, NY. Plenum.

Bourdieu, Pierre (1977) *Outline of a Theory of Practice.* Cambridge. Cambridge University Press.

Bourdieu, Pierre (1990a) *In Other Words. Essays Towards a Reflexive Sociology.* Cambridge/Oxford. Polity Press.

Bourdieu, Pierre (1990b) *The Logic of Practice.* Stanford. Stanford University Press.

Fuchs, Christian (2002a) *Some Implications of Anthony Giddens´ Works for a Theory of Social Self-Organisation.* INTAS Project "Human Strategies in Complexity"-Research Paper. In: Emergence, Vol. 4, No. 3, pp. 7-35.

Fuchs, Christian (2002b) *Some Implications of Pierre Bourdieu´s Works for a Theory of Social Self-Organisation.* INTAS Project "Human Strategies in Complexity"-Research Paper. In: European Journal of Social Theory, Vol. 6, No. 4 (forthcoming).

Fuchs, Christian (2002c) *Concepts of Social Self-Organisation*. INTAS Project "Human Stretegies in Complexity"-Research Paper No. 4. http://www.self-organisation.org/results/papers/papers/pdf/hsicpaper4.pdf

Fuchs, Christian (2002d) *The Role of the Individual in the Social Information Process*. In: Entropy (http://www.mdpi.org/entropy), Vol. 5, No. 1., pp. 34-60.

Fuchs, Christian (2002e) *Krise und Kritik in der Informationsgesellschaft. Arbeiten über Herbert Marcuse, kapitalistische Entwicklung und Selbstorganisation.* Norderstedt/Vienna. Libri BOD.

Fuchs, Christian (2002f) *Modern Society – A Complex, Evolutionary, Self-Organising, Antagonistic System.* INTAS Project "Human Stretegies in Complexity" (http://www.self-organisation.org) Research Paper. Publication forthcoming.

Fuchs, Christian (2003a) *Structuration Theory and Social Self-Organisation.* In: Systemic Practice and Action Research, Vol. 16 (2003), No. 2, pp. 133-167.

Fuchs, Christian (2003b) *Co-operation in Complex, Self-Organising Systems.* In: Triple C: Cognition, Communication, Co-operation. Vol. 1 (2003), No. 1 (forthcoming).

Giddens, Anthony (1981) *A Contemporary Critique of Historical Materialism. Vol. 1: Power, Propert and the State.* London/Basingstoke. Macmillan

Giddens, Anthony (1984) *The Constitution of Society.* Berkeley. University of California Press.

Giddens, Anthony (1985) *A Contemporary Critique of Historical Materialism. Vol. 2: The Nation-State and Violence.* Cambridge. Polity Press

Giddens, Anthony (1993) *Sociology.* Cambridge. Polity Press.

Habermas, Jurgen (1984) *The Theory of Communicative Action*. Boston. Beacon Press. Vol. 1

Haralambos, Michael/Holborn, Martin (1991) *Sociology. Themes and Perspectives.* London. CollinsEducational.

Jantsch, Erich (1979/1992) *Die Selbstorganisation des Universums. Vom Urknall zum menschlichen Geist.* München/Wien. Hanser.

Lévy, Pierre (1997) *Collective Intelligence. Mankind´s Emerging World in Cyberspace.* New York. Plenum.

Luhmann, Niklas (1984) *Soziale Systeme – Grundriss einer allgemeinen Theorie*. Frankfurt. Suhrkamp.

Luhmann, Niklas (1986) *Die Unwahrscheinlichkeit der Kommunikation*. Opladen. Westdeutscher Verlag.

Luhmann, Niklas (1988) *The Autopoiesis of Social Systems.* In: Geyer, Felix/van der Zouwen, Johannes (Eds.) (1988) *Sociocybernetic Paradoxes. Observation, Control and Evolution of Self-steering Systems.* London. Sage. pp 172-192

Oberquelle, Horst (1991) *Kooperative Arbeit und menschengerechte Groupware als Herausforderung für die Software-Ergonomie*. In: Oberquelle (Ed.) (1991) *Kooperative Arbeit und Computerunterstützung. Stand und Perspektiven*. Göttingen/Stuttgart. Verlag für Angewandte Psychologie. pp. 1-10.

Schmidt, Kjeld/Bannon, Liam (1992) *Taking CSCW Seriously - Supporting Articulation Work*. In: Computer Supported Cooperative Work (CSCW), Vol. 1 (1992), No. 1-2. pp. 7-40.

Shannon, Claude E., and Weaver, Warren (1949) *The Mathematical Theory of Communication*. Urbana. University of Illinois Press.

Stockinger, Gottfried/Fenzl, Norbert (1992) *A inversäo dos tempos – O movimento inteligente*. Belém.

Stockinger, Gottfried (1998) *The role of variety in the evolution of information society*. In: World Futures, 1998, Vol 50, p. 715 – 729. Gordon and Breach. Amsterdam.

Stockinger, Gottfried (2001) *Para uma teoria sociológica da comunicação*. e-published at:
www.facom.ufba.br/Pos/gottfried.pdf Salvador. Universidade Federal da Bahia.

Wallerstein, Immanuel (1974) *The modern world-system. Capitalist agriculture and the origins of the European world-economy in the sixteenth century*. New York. Academic Press.

Action, Communication, and Creativity[1]. A Contribution from a Meadean Perspective

Franz Ofner

Introduction

This paper focuses on some theoretical aspects of action and communication processes which are relevant for conceptualising the self-organisation of social systems. There are three questions I shall deal with:
What is the relation between action processes and communication processes?
How is understanding between human actors possible?
What is the foundation of creativity in human action and communication?

If we describe social systems following Fuchs and Stockinger (cf. their paper in this volume) in accordance with the principles of action and communication and if we do not want to fall back into dualism, we have to show that both processes are not separate ones. We need to show that both kinds of processes follow from one and the same principle, work with the same contents, have the same structure and differ only in the form of the way they are carried out. This primciple that is the condition for actors to close up actions and communication processes and to co-ordinate their interactions by the use of symbols; is as well the condition for social structures to do both: exist in and through action and be based on communication processes. If there is a transition from action to communication and vice versa these two kinds of processes need to have common contents and structures.

If we presume that communication is uncertain and unsteady the question arises how understanding can be achieved, however partial and temporary it may be. It is a matter of how the actors constitute common meanings of symbols or modify existing meanings so that what one says is interpreted in the same sense by all involved, including the speaker.

The self-organisation of social systems involves the production and change of social structures and of the environment, and is so characterised by creativity on both levels: the level of action and the level of communication. On the level of communication creativity consists in attributing meaning to members of society and to the physical objects and in modifying attributed meanings. On the level of actions creativity consists in reflecting and restructuring the sequences of action impulses and in making new fields accessible for activity. The question arises

[1] I express my gratitude to my colleague and friend Josef Mitterer, University of Klagenfurt, for helping me to put my thoughts into comprehensible English.

which characteristics of human action and communication are conditioning this capacity of reflection and creativity.

I shall deal with these problems on the basis of the social theory of George Herbert Mead[2]. Mead has drawn up the outlines of a social theory which aims at overcoming the dualisms of traditional social science: the dualism of mind and body and the dualism of individual and society. He pays special attention to the problem of creativity of human action and communication.

Gestures as Foundation of Communication

In his attempt to overcome the dualism of mind and body, Mead decides to choose a materialistic way for solving the problem: Mind is not an immaterial substance separated from the organism transforming the physiological processes of perception into conscious experiences and giving meaning and purpose to human action, rather mind is a characteristic or capacity of the human organism which has emerged in the process of phylogenetic evolution and continues to develop in the process of ontogenesis. Mead tries to explain the genesis of consciousness along with the development of communication from the animal form of the “conversation of gestures” to the human form of communication mediated by symbols. In his discussions Mead refers on several occasions critically to Charles Darwin and Wilhelm Wundt.

With the model of the conversation of gestures Mead goes beyond the dualism of individual and society and gives a consequently inter-subjective approach. The basic category of his theoretical considerations is formed by social actions; he does not conceive animals as socially independent individuals who are separated from each other and only then start having contact with each other. He holds the opinion that animals are social beings and are endowed with certain abilities which mediate and structure their social behaviour. These social abilities are what we call instincts and impulses. In social actions the individuals are objects for each other. Examples are wooing and sexual behaviour, nourishment and various forms of child care, formation of habitats, mutual grooming, common plays, attack and defence. In other words, social actions are actions in which several animals (at least two) participate and where the activities of the animals are stimuli to responses. Social actions are initiated and mediated by gestures. A gesture is the (frequently stylised) beginning of a certain act and results in certain responses of the other animals. What follows is a "conversation of gestures" which we can imagine more or less as

[2] For better readability, I abstain from giving detailed references of Mead´s work within the text. Confer the literature at the end of this paper.

follows: animal A starts acting with animal B; B already responds to the beginning of A´s act, that is his gesture, and interrupts A´s act; A responds, in turn, to B´s gesture, and so on. By such conversation of gestures, animals are able to modify or adjust to each other their mutual behaviour.

Animals interpret the gestures of other animals by responding to them. The gesture of the one individual has an information value for the other individual by indicating to him what the individual making the gesture is going to do. We do not assume that this interpretation is conscious, rather it is an instinctive interpretation carried out in terms of behaviour. The interpretation would only be conscious if the responding animal presented to himself the act which follows upon the gesture before reacting to it. And we do not assume that the animal making a gesture knows which action it indicates to the other individual.

Once the individual becomes aware of the information value the gesture gets a meaning. Mead speaks of significant gestures or symbols if the meaning is the same for both the individual making the gesture and the individual being addressed. The conversation of gestures has, according to Mead, already the structure of meaning although it is not conscious to animals. Meaning consists of a triadic relation: between the gesture of one animal and the response of another animal, between the gesture and the act, which is initiated by that gesture, and between the response and the act which is initiated by that gesture. In the case of the conversation of gestures, the meaning-components are distributed to different individuals as the value of the gesture is different for the individuals involved: The making and interpreting of signs is attached to different individuals and each gesture has a different value for the individuals involved because they initiate different acts. If, for example, animal A starts an attack through its gesture and animal B responds by turning to fleeing then the gestures have different values for the individuals involved. There is no common meaning because none of the individuals is able to present to himself the relation that leads from gestures to acts.

Symbols as Initiated and Inhibited Actions

In Mead´s concept of the conversation of gestures, a gesture forms a part of an action: it is the beginning of the act and it is part of the attitude that an individual assumes when starting the act; the meaning of a gesture is the action mediated by the response of the other individual. Thus, gesture, response, and meaning make up a complete action which, however, is not carried out, but only initiated. The contents of the conversation of gestures are of the same kind as those of actions. Conversation of gestures is social action and is the predecessor of conscious communication. Conscious communication is characterised by the fact that the signs have the same meaning to all individuals: to those who make the signs and to those who are addressed.

How can gestures become significant and how can meaning become conscious for the involved individuals? In the conversation of gestures, it is the response that gives an information value to the gesture. Consequently, it is a precondition for an individual to understand his own gesture that he responds to his own gesture in the same way as other individuals do. Mead considers this condition fulfilled if individuals make use of gestures that they can perceive themselves: vocal gestures or gestures involving hands and arms. If individuals can perceive their own gestures they can respond to them like other individuals belonging to the same species. Using a vocal gesture an individual stimulates himself and arouses an impulse in himself which is the same one he arouses in other members of the same species addressed by the same gesture. The individual responds only implicitly to its own gesture, that is, the response is not carried out, only his central nervous system has been activated. On the other hand the individual addressed by the gesture responds in an explicit manner. This procedure enables the individual making the gesture to participate in the other´s response. The consequence is that the individual assumes the same attitude towards his own gesture as other individuals do.

The mechanism of taking the attitude of the other towards his own gestures is the core of Mead´s approach to explain the emergence of meaning and significant symbols. However, this mechanism cannot completely solve the problem of the genesis of consciousness and significant symbols. Additional conditions have to be met:

The individuals need to relate the gestures and the responses with the initiated social action, and

each individual needs to know that the other individuals involved give the same meaning to the gestures as he does; they need to have a procedure to clear up their meanings to another.

Mead did not develop a systematic concept concerning the genesis of consciousness and significant symbols; what he offers is the mechanism of internalisation. The idea of this particular mechanism is that the structure of the conversation of gestures taking place among individuals in an external process is imported into the individuals, into their organism, and eventually turns into an internal process. The basis of internalisation processes is the mechanism of taking the attitude of the other: An individual who participates in the others´ responses to its own gestures has already taken the first step to internalise them. The second step would be to respond to its own gestures independent from the others´

reactions. A precondition of this step, however, is that the individual is a social object to himself. This problem was called by Mead the problem of the genesis of the self (see below).

However, there is another problem regarding the genesis of consciousness: According to the assumption of the conversation of gestures an individual is not conscious of the interpretation it makes when responding to a gesture; the same is the case if an individual responds to its own gesture: this fact does not render the information value conscious. The difficulty regarding the issue of consciousness of meaning is that individuals have to establish a link between the gesture and the action, which is not present at the moment of perceiving the gesture but will (perhaps) appear in the future. This difficulty could be the reason why Mead reduced his concept of meaning to a behaviourist concept in exactly that moment when he starts explaining how meaning becomes conscious. As mentioned, the initial formulation of the meaning problem by Mead is triadic: as a relation between the gesture, the social act initiated by the gesture and the response to the gesture. However, when the solution of the meaning problem is to be presented, meaning is restricted to a relation of gesture and response. The consequence is that the common social act, which is relevant for the development of the significance of symbols, for acting purposively and for a conscious co-ordination of acts, has disappeared

We can get closer to a solution of the problem of consciousness if we use Mead´s concept of imagery. According to Mead, the central nervous system is able to store experiences; in recent actions experiences are recalled in the form of images, they enter into and complement in the same time the processes of perception – imagery is built up from past experiences and accompanies current actions and helps the individual to pick out appropriate stimuli from the environment; if already initiated acts are inhibited then the contents of imagery and perception do not match each other and the imagery gets separated from the content of perception. In the conversation of gestures the individuals inhibit their acts mutually by responding to the gestures of each other. On the basis of these assumptions, it would be plausible that gestures and their responses can create images of those social actions they belong to. This is the way, how the meaning of gestures is internalised[3].

[3] I do not discuss the problem of the reductiveness of Mead´s concept of consciousness. I think imagery alone does not suffice to describe what kind of experience consciousness is. My objection is that imagining a content instead of perceiving it does not render it conscious. It is necessary to relate images to possible perceptions.

The constitution of meanings is, according to Mead, not an individual but a social process arising in processes of communication and social actions. A test whether other persons connect the same meaning with a verbal expression can only be carried out within communication: via their responses and via fulfilment or lack of fulfilment of their expectations concerning actions. Misunderstandings and incomprehensible expressions are unexpected answers or acts. Understanding, if at all, becomes possible only by communication processes in the context of social actions.

Self-consciousness

According to the concept of communication as developed up to now, the vocal gesture initiates an image in the individual who made the gesture. Making the gesture is, however, fixed to the presence of another individual who stimulates the gesture and to whom the gesture is directed. This means that the individual is not able to indicate something to itself outside of a direct communication process with other individuals. An individual at this stage of development has not yet internalised the complete structure of the conversation of gestures; it is not able to differentiate between the other and itself and, therefore, to communicate with itself.

Mead develops an elaborate theory of the development of self-consciousness. This theory is again based on the mechanism of taking the attitude of the other. Children experience the responses of their parents and other adults in the processes of social actions and communication. According to the mechanism of taking the attitude of the other they learn to participate in the responses of the adults and to develop their own images of these responses. They tend to reproduce the responses of their parents in situations where they want to turn to their parents. This behaviour is developed further into a play in which they take the role of their parents and other adults and enter into communication with themselves: they speak to their parents and answer themselves as parents, they perceive their own verbal expressions as those of themselves and those of their parents. In this way, they learn to distinguish between themselves and other persons and become a social object for themselves. The action and communication processes they are involved in, give meaning to others and themselves.

Mead distinguishes plays from games. A play means the taking of another person´s role whilst "game" describes the situation of a group where the act of one member calls out a larger number of responses: not only towards the one who acted first but also among the other members of the group. Team games in sport and dramatic games are examples. Thus, the typical contents of games are not dyadic relations but rules which are followed in social relations. Games enable children to build up their own self in confrontation with social structures.

According to Mead it should be stressed that, in contrast to individualist social theories, self and self-consciousness are completely social creations: they arise through social actions and communication processes by participating in the others´ responses to our acts. Therefore at least to some extent, our selves bear the meaning that we have to others.

Reflexivity and Creativity

Inhibition of action is one of the conditions for the emergence of consciousness of meaning. Inhibition takes place in the social process through the responding gesture of one individual towards the gesture of another. The process of internalisation and creating a self enables us to inhibit our own acts. Communication is an inhibited form of acting: communication happens in form of attitudes, that is, in form of initiated actions which have not been carried out.

The inhibition of actions and its moving into the sphere of imagery is the basis of the development of reflexivity and creativity. Self-conscious individuals are able to indicate their own behaviour to themselves via language before acting. Stepping out of the sphere of direct acting and entering the sphere of symbolic acting allow us to analyse the situation in which the action takes place: to identify different characteristics of the situation, to break down the action in parts, to remember past experiences and to test all that for its practicability, and furthermore to restructure the components "in the mind" for creating new acts and meanings. At the stage of consciousness, the mechanism of trial and error is substituted by thinking.

Mead holds that thinking arises from the communication process and follows its pattern: it is a kind of talking to oneself. Thinking without symbols is not possible. This is the reason why thinking can turn into communication with others. Thinking and communication are not disparate processes but have the same structure and deal with the same contents.

Reflexivity and creativity belong together. In reflexive processes an individual activates his past experiences and transforms them into conscious experiences by indicating to himself his behaviour towards the perceived characteristics of the situation. Creativity is oriented towards the invention of new characteristics in the environment and adequate responses to them: creativity is problem solving. It is inherent to Mead´s theory that acting is always spontaneous, as it is a secondary process which renders action impulses conscious – however, they do not become conscious in all cases but only if they have been involved in communication processes and are transformed in symbols. We are not conscious of all of our behaviour, and a great deal of it is made of habits and is carried out automatically. Problematic situations which impede our actions are the precondition for the process of giving conscious meaning to actions and objects.

Conclusion

Mead´s social theory allows to conceptualise self-organisation and the structure of social systems in accordance with both principles, action and communication, without falling back into dualism. Following Mead, communication is only another form of action: Phylogenetically, communication has emerged from social acting by separating the phases which initiate acts from the carrying out of the action process and by constituting these phases as gestures. Thus, the contents of communication are attitudes, that is, initiated and potential acts.

The transition to gestures which can be perceived by the individuals making them is a precondition for the evolution of conscious communication and acting: individuals can respond to their own gestures and take the same attitude towards them as other individuals of their species. In this way they get information about their own behaviour. The internalisation of the conversation of gestures and the emergence of imagery are additional mechanisms for developing consciousness of meaning and self-consciousness. Self-consciousness permits the individuals to communicate with themselves, that is, to reflect their own acts.

Thus, actions, communication and thinking share the same structure and relate to the same contents. This allows individuals to change between acting, communicating and thinking, to co-ordinate their acts via communication and to prepare acts and communication via thinking processes.

Understanding between human actors is possible because of social acts which constitute the meaning of symbols and objects. The individuals gain experience about their own behaviour via the reactions of other individuals to their behaviour. Thus, behaviour and verbal expressions of other individuals inform us not only about them but also about ourselves. And this is the common foundation on which understanding can develop.

Human creativity is based on the temporary suspension of acting through communication and thought. Suspension of acting provides room to analyse and restructure objects and situations, to invent and test new combinations of acts.

References:

Mead, George Herbert (1909) *Social Psychology as Counterpart to Physiological Psychology*. In: Psychological Bulletin 6 (1909). pp. 401-408.

Mead, George Herbert (1910) *Social Consciousness and the Consciousness of Meaning*. In: Psychological Bulletin 7 (1910), pp. 397-405.

Mead, George Herbert (1913) *The Social Self*. In: Journal of Philosophy, Psychology and Scientific Methods 10, (1913). pp. 374-380.

Mead, George Herbert (1922) *A Behavioristic Account of the Significant Symbol*. In: Journal of Philosophy 19 (1922). pp. 157-163.

Mead, George Herbert (1925) *The Genesis of the Self and Social Control*. In: International Journal of Ethics 35 (1925). pp. 251-277.

Mead, George Herbert (1967) *Mind, Self, and Society from the Standpoint of a Social Behaviorist*. Edited by Charles W. Morris. Chicago/London. The University of Chicago Press.