Double Shell Structure of the Periodic System of the Elements *

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A new periodic system of the elements (PSE) is proposed which exhibits symmetry properties not apparent in the conventional arrangement of the elements. By discussing the solutions of the non-relativistic Schrödinger equation for the Coulomb problem it is shown that the PSE might be based on the filling of only four Coulomb shells as compared to the partial filling of up to eight shells in the conventional classification. On the other hand, the multiplicity of the states in the PSE appears to be four as compared to two due to spin in the hydrogen spectrum. A transformation of the PSE-spectrum into the hydrogen spectrum is possible by a rotation in quantum number space.

1. Introduction

The Periodic System of the Elements (PSE) reflects the order of filling of the electron shells and subshells. It is a generally accepted rule that this order is *in principle* identical with the sequence of the electronic states in the hydrogen atom. The well known exceptions from the expected order of filling occuring in the PSE are ascribed to the modification of the unscreened Coulomb field due to the presence of other shell electrons and to the interactions among these electrons and have been justified by detailed calculations of the energies involved.

However, the exceptions from the rule in the second half of the PSE are so numerous that one might well ask: Is the sequence of the hydrogen states really the underlying principle in the build up of the PSE or is it possible to find a more adequate principle?

In persueing this question, we concentrate on the major exceptions where complete subshells are filled against the rule, e. g. the filling of the 4s subshell before the 3d subshell. We shall neglect the minor irregularities occuring within some of the subshells; especially, with respect to the beginning of the lantanides, La is taken to be the first element with an electron in the 4f subshell, since here the intermediate occupancy of a 5d state can be considered as a minor exception similar to that occuring in the case of Gd at the center of the lantanides.

It is evident that the problem of finding a simple build up principle implies a rearrangement of the conventional PSE.

After a suitable system is presented in Sect. 2, the dependence of some properties of the elements on their position in the new PSE will be discussed in Sect. 3. In Sect. 4 the solutions of the Schrödinger equation for a Coulomb potential will be discussed and it will be shown that both the PSE-spectrum and the hydrogen spectrum are solutions of the Coulomb problem. The spectra transform into each other by a rotation in quantum number space.

2. Formal Description of the New PSE

The new PSE is shown in Fig. 1. It is obtained by first turning the conventional system up side down in order to obtain the correlation between energy and quantum numbers in a customary way. Then the group I and group II elements are pulled one unit down and written to the right of the other elements.

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[1] E. MADELUNG, Die mathematischen Hilfsmittel des Physikers, Springer-Verlag, Berlin 1950, p. 611. See footnote p. 670 in [2] for the early reference in 1926.

[2] S. A. GOUDSMIT and P. I. RICHARDS, Proc. Nat. Acad. Sci. US 51, 664 [1964].