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EXPLANATION FOR THE ASYMMETRY BETWEEN MATTER AND ANTIMATTER IN THE VISIBLE UNIVERSE *

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ABSTRACT

Quantum spin 1/2 is interpreted as an "orbital" motion in a multiply-connected Kerr space-time. This leads to a natural explanation of the lack of astrophysically significant amounts of antimatter in the visible universe.

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Steigman[1] has presented a persuasive case that there is no astrophysically significant amount of antimatter in the visible universe. I first summarize his argument and then offer an explanation in terms of the global topology of the space-time of a geometrodynamic ("mass without mass"[2]) black hole.

Steigman[1] cites several pieces of direct evidence for the lack of antimatter: 1) no antinucleus has ever been found in cosmic rays; 2) the Faraday rotation of polarized electromagnetic radiation in magnetized interstellar plasma is large (if there were an equal number of electrons and positrons this would not be the case); 3) matter-antimatter annihilation gives about four gamma rays of energy > 70 MeV.[3] The observed gamma spectrum does not indicate a significant number of annihilations.

Theoretically, the standard hot big bang cosmological model assumes matter-antimatter asymmetry as an ad hoc initial condition and the present epoch has no astrophysically significant amount of antimatter. Steigman concludes "the evidence seems to indicate overwhelmingly that our universe is not symmetric".[1]

Assume that the universe at t = 0 consists of a "crystal" of 10^{61} quantum black holes, each of mass 10^{-5} gm in a ball of about 10^{-13} cm across. The minimum size of 10^{-13} cm is consistent with the Einstein-Cartan geometry with curvature and torsion.[4] The quantum black holes are assumed to satisfy the Kerr solution in the regime $a > m$ as pictured in Fig. 1, where a is the angular momentum per unit mass and m is the mass (both with the dimensions of a length). The quantum black hole can be pictured as a photon (or a neutrino) running around the edge of the Kerr disc $x^2 + y^2 < a^2$, $z = 0$ in Kerr-Schild co-ordinates.[5] The circulating energy of the trapped photon creates the Kerr space-time. The ring singularity is a breakdown of classical physics. Thus, this is a quantum ansatz. There has recently been considerable interest in dual light strings[6] as models for hadrons in which the basic dynamical process is the breaking of a massless relativistic string. The dual string models run into trouble because of the use of the inhomogeneous Lorentz group which is not appropriate to curved space-time. The quantum black hole formed from a light string round the Kerr disc can have a total spin of 1/2 even though the photon spin is 1. This is because the orbital contribution to the angular momentum of the light string can be 1/2 . The restriction of orbital angular momentum to integer spins follows from the requirement of single-valuedness of the wave function and the implicit assumption of a simply-connected Euclidean topology of space-time. The Kerr space-time has a double-sheeted non-Euclidean topology. Thus, the light string can make a complete 2π circuit round the edge of the Kerr disc on the positive mass space-time sheet. It can then cut below the Kerr disc and make a second 2π circuit round the edge of the disc in the negative mass space-time sheet before cutting through the disc a second time to smoothly join the point at which the string began. Now imagine fitting a single complete DeBroglie wave round the complete 4π circuit passing through both universes. An observer in the positive mass sheet sees only a half DeBroglie wave fitting round the Kerr disc with a singular point at which the slope of the wave function is discontinuous. The wave function has two branches on the positive mass sheet corresponding to spin up and spin down. In the maximally extended space-time, the wave function is single-valued and its slope is continuous everywhere. Thus, quantum spin 1/2 can be interpreted as a space-time motion in the double-sheeted Kerr space-time. This is the space-time significance of Pauli's "non-classical two-valuedness". In particular the quantum black hole can have a spin of 1/2 or 3/2 if it is a single string of light. The ratio of Kerr parameters for the light string passing through both universes is

$$a/m = \lambda^2 c^3/Gh > 1 \quad , \qquad (1)$$

where λ is the photon wavelength.

The quantum black hole is the Kerr disc in the positive mass sheet. The antiquantum black hole is the Kerr disc in the negative mass sheet. Virtual time-like photons ($Q^2 > 0$) can pass through the Kerr disc and give particle-antiparticle pairs each of positive mass.

Thus, at cosmic time $t = 0$, the quantum black hole crystal ball does not have any anti-black holes in it. We observe the remnants of the ball from the positive mass side. The antimatter is there but it is in another universe connected with our own through the Kerr discs of strings of light. One might call this the "Crystal Ball Magic Looking Glass Cosmology", with apologies to the late Professor Charles Dodgeson!

ACKNOWLEDGMENTS

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REFERENCES AND FOOTNOTES

1) G. Steigman, "Antimatter in the universe", ICTP, Trieste, Internal Report IC/73/110.

2) J.R. Klauder, Ed., Magic Without Magic (W.H. Freeman,1972).

3) M.H. MacGregor, in Lectures from the Coral Gables Conference 1971 (Gordon & Breach/1971), Vol. 3, pp. 75-154, has classified 140 hadron resonances assuming two spinless mass quanta at 70 MeV and 210 MeV, as well as a spin 1/2 quantum at 327 MeV. We can imagine these mass quanta to be low-energy strings made from photons, neutrinos and electric flux trapped in the multiply-connected topology of the Kerr discs. The strings are knotted together in the bound hadronic states. For example, consider a proton-antiproton annihilation forming six pions. The transition from protons to pions can be pictured as a rearrangement of the strings. The decay of the two neutral pions to 70 MeV gamma rays can be pictured as photon strings that break apart. The decay of the charged pions to neutrinos and electrons (positrons) represents broken neutrino strings. The electrons (positrons) are unbroken strings with trapped electric flux.

4) A.Trautman, Nature Physical Science 242, 7 (1973).

5) S.W. Hawking and G.F.R. Ellis, The Large-Scale Structure of Space-Time (Cambridge University Press,1973).

6) P. Goddard, J. Goldstone, C. Rebbi and C.B. Thorn, "Quantum dynamics of a massless relativistic string", Nuclear Physics B56, 109 (1973);
S. Mandelstam, Berkeley preprint (1973).

Fig. 1 Double-sheeted Kerr space-time for $a > m$. Quantum spinor ($S = 1/2$) describes "orbital" motion in a multiply-connected space-time. The maximal extension of the Kerr solution for $a > m$ is obtained by identifying the top of the disc $x^2 + y^2 < a^2$, $z = 0$ in the (x,y,z) plane with the bottom of the corresponding disc in the (x',y',z') plane and vice versa. On circling twice round the singularity at $x^2 + y^2 = a^2$, $z = 0$, one passes from the (x,y,z) universe to the (x',y',z') universe (where m is negative) and back to the (x,y,z) universe (where m is positive). When m is very small compared with a, the space-time sheets outside of the Kerr disc are essentially flat. (See also Ref. 5, p. 163.)

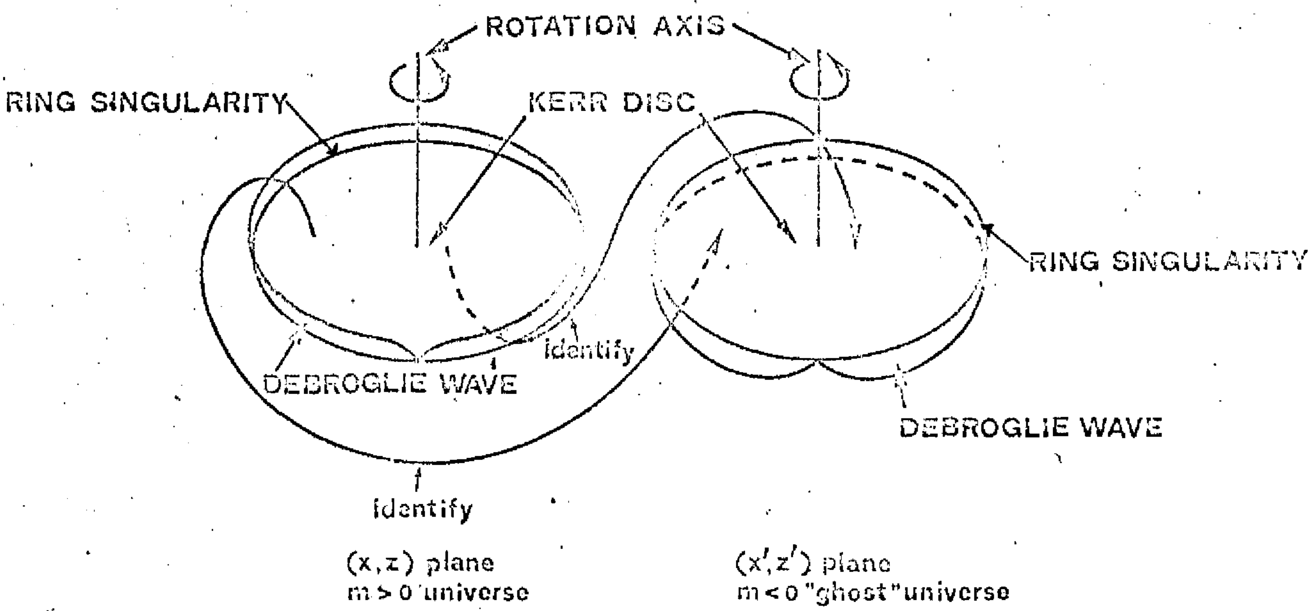

FIG. 1