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On a Possible Parity Non-Conservation in Gravitational Interactions

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Abstract: It is emphasized that antigravity (an effective repulsion of antiparticles) is a consequence of gravity invariance relative to the time reversal T. This allows one to distinguish true elementary particles from antiparticles among mesons. Attention is given to a possible violation of T-symmetry and parity non-conservation in gravitational interactions. This makes a search for antigravity a paramount task.
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This question has been touched upon earlier [1] in connection with the antigravity problem. In view of its exceptional importance, we consider it specially.

Antigravity

Recall that the prediction of this phenomenon is based on the representation that antiparticles are products of the Minkowski space symmetry relative to relativistic reflection (4-inversion) R=PT [2]. Here P is space reflection (parity), T is the inversion (sign change) of time. As a result of reflection $x^i \to -x^i$, the 4-velocity

$$u^i = (u^0, u^\alpha) = dx^i / d\tau \quad , \tag{1}$$

(where $x^i=(x^0, x^\alpha)$; α=1,2,3; τ is the invariant proper time) of antiparticles has the opposite sign

$$u_a^i = -u^i . \tag{2}$$

In particular, the negative sign of the time component u_a^0 (the energy) says that time flows backward for antiparticles (the known Stueckelberg-Feynman interpretation). Thus, *antiparticles are particles with negative energy for which time flows backward*. Taking into account aforementioned, we consider the relativistic equation for the gravity force [3] (an analog of the relativistic Lorentz force)

$$\vec{F} = -mu^0 \vec{E}_g / c. \tag{3}$$

Here $\vec{E}_g$ is the strength of a gravitational field (GF). For antiparticles

$$u_a^0 = -u^0 = -\gamma c, \tag{2'}$$

where γ is the Lorentz-factor, and therefore

$$\vec{F}_a = -mu_a^0 \vec{E}_g / c = mu^0 \vec{E}_g / c = -\vec{F} \tag{4}$$

(gravitational repulsion). As seen, there is no necessity at all to ascribe a negative mass to antiparticles (this is a direct consequence of the famous formula $E=mc^2$ since the antiparticle energy is negative). In particular [4], one says about "… the apparent appearance of "positive electrons", which should be, in any case, understood as electronegative particles with a negative mechanical mass". The latter assertion is saved as a main argument against antigravity (see [5, 6]).

Return now to Eq.(4) and consider the π^0-mesons behavior in GF. On the grounds of T-symmetry, π^0-mesons with negative energy, i.e. $\tilde{\pi}^0$-mesons repulsed by the external GF, must exist side by side with "usual" ones. At first sight this picture seems absolutely absurd. This reason induced me at one time to be thoughtful as to whether the gravitational interaction is invariant relative to the time reversal [1]. Later on, however, the previous impression has changed as a result of the reflection on the famous Dirac statement, "… an electron with negative energy moves in an external field as if it bears a positive charge" [7]. The sense of the subjunctive mood of this statement is easily understood of one applies to the relativistic equation for Lorentz's force

$$\vec{f} = eu^0 \vec{E} / c, \tag{5}$$

where $\vec{E}$ is the electric field strength. For the anti-electron, i.e. the electron with negative energy, we have

$$\vec{f}_a = eu_a^0 \vec{E} / c = e(-u^0) \vec{E} / c = (-e)u^0 \vec{E} / c. \tag{6}$$

The latter expression can be indeed treated as if this electron bears a positive charge. However, this does not give any grounds to name it a positron and to consider as an independent elementary particle.

Let us present Eq.(4) like (6) in the form

$$\vec{F}_a = -(-m)u^0 \vec{E}_g / c. \tag{4'}$$

Whence we conclude that a particle with negative energy moves in GF as if it has a negative mass (negative "gravitational charge") [3], i.e. it must be repulsed by this field.

Remark that the change of charge sign (the operation of charge conjugation C) in the latter expression of Eq.(6) or in Eq.(4') leads us to initial Eqs.(5) and (3), respectively. It is the manifestation of the known CPT-theorem.

Particles and Antiparticles

Thus, as we have ascertained, gravity has an unique property. One can judge by the behavior of elementary particles in a GF which of them are true (attraction) and which are antiparticles (repulsion). However, as far as one knows, similar experiments have not been performed yet because of great difficulties. Therefore the contemporary division of elementary particles (especially between mesons) into particles or antiparticles has some elements of arbitrariness. In this connection, let us consider two known decays: $\mu^- \to e^- \nu \tilde{\nu}$ and $\pi^- \to \mu^- \tilde{\nu}$. In the first case, both the initial μ^-- meson and the products of its decay - electron are attracted by a GF. However, in the second decay the π^--meson is (according to contemporary representations) an antiparticle and must be repulsed by a GF. Thus, the weak interaction changes radically the nature of gravitational interaction which looks unnatural. It is logical to suppose that the initial particle (π^--meson) is a true one as in the first case. Confirming similar reasonings conformable to other decays, we have the following table for main true particles (leptons and mesons)

$$e^-, \mu^-, \tau^-; \pi^-, \pi^0; \rho^-, \rho^0; K^-, K^0; D^-, D^0; B^-, B^0 \text{ and so on} \quad (7)$$

Attention is given to all charged particles that bear a negative electric charge. What is more, strange, charming, and beautiful mesons have the corresponding negative quantum numbers. The exceptional shapeliness of this picture raises confidence in its truth.

Possible Parity Non-Conservation

As noted earlier [1], the antigravity prediction is in fact based on the assumption that gravity is invariant relative to time reversal. But there are now no experimental evidences of gravitational interaction invariance relative to the change of time sign and the inversion of space coordinates (parity conservation). In this connection, we remark the following [2].

Relativity theory has ascertained (by means of the Lorentz transformations) a close relation between space and time coordinates. The corresponding operations over them (space reflection P and time reversal T) must also be interrelated. Just as x^α and t are the world line projections, P and T are the projections of the 4-inversion R=PT. Therefore, the T-symmetry violation means automatically the R non-conservation and, consequently, parity P non-conservation as its projection.

Conclusion

The antigravity prediction is based on the supposition that the gravitational interaction is an invariant relative to the time reversal. As a consequence of antigravity, for example, π^0-mesons with negative energy must be repulsed by a GF. We have no proofs now that the gravitational interaction is invariant relative to the reflection of space and time coordinates. Maybe it is an analog of the weak interaction. Therefore, the investigation of the antiparticle behavior in a GF is an actual task of our time.

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