The Principal Solution of the Greatest Problem in Physics (Quantum Gravity)

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Abstract: The calculation of the gravitational shift of photon frequency forms the foundation for the quantum theory of gravity. The 4-vector nature of the gravitational field (its time component is Newton's potential) is its consequence. As a result, the previous difficulty of gravitational field quantization in general relativity (connected with metric quantization) is removed. That opens up the way to the construction of a united theory for all of the fundamental interactions.

A hundred of leading physicists asked by Physics World, named quantum gravity as the first one among the greatest unsolved problems in physics [1]. However, it has recently become clear [2] that the foundation for this theory has already been laid down in the explanation of the gravitational shift of light's frequency in the framework of *relativistic gravidynamics* (RGD) or the Lorentz-covariant theory of gravity [3] based upon the law of energy conservation (e.g., [4] & [5]).

Recall that, for example, we have the balance of energies

$$M^*c^2 + M^*\Phi = Mc^2 + M\Phi + h\nu_g, \qquad (1)$$

at photon emission by an excited atom of mass M^* in a gravitational field with potential Φ. Whence the known equation of gravitational red shift

$$\nu_g = \nu(1 + \Phi / c^2) \qquad (2)$$

follows directly.

But according to *general relativity* (GR), the right side of eq.(1) is not equal to the left one (the energy conservation law is violated) since the photon potential energy is not taken into account on the right. Adding it, we have:

$$M^*c^2(1 + \Phi / c^2) = Mc^2(1 + \Phi / c^2) + h\nu_G + h\nu_G\Phi / c^2 . \qquad (3)$$

As a result, after contraction by the quantity $(1+\Phi/c^2)$, we obtain the expression

$$M^*c^2 = Mc^2 + h\nu_G, \qquad (4)$$

answering the energy balance at the photon emission in the absence of a gravitational field. Thus, according to GR, the gravitational frequency shift does not take place:

$$\nu_G = \nu. \qquad (5)$$

This contradicts directly the experiments [6-8] that were done with atomic clocks (whose base are quantum standards of frequency). Recall that the gravitational change

of its rate is just conditioned by changing the quantum transition frequency according to eq.(2).

Only RGD with its gravitational charge-mass and 4-vector gravitational potential (its time component is Newton's potential) provides a correct balance of energies (1). And the observed gravitational shift of frequency as described by eq.(2), confirms its justice. This is because we must take into account that energy is the time component of a 4-vector and based on eq.(1), where we have for the 4-vector of potential energy-momentum

$$p_g^i = m\Phi^i$$
, (6)

where the product of the gravitational charge and potential figures are on the right and according to eq.(6) the photon potential energy is equal to zero.

A remarkable likeness of RGD with electrodynamics allows one to conclude that the quantum of the gravitational field - the graviton (as a photon) has zero mass and a spin of 1.

The corresponding quantum theories quantum electrodynamics and quantum gravidynamics (QED and QGD respectively) conserve a similar likeness. What is more, the QED section of particle field quantization transits to the QGD section unchanged. Only the terms 'electromagnetic', 'photon', and 'electromagnetic 4-potential A_i' should be replaced by the terms 'gravitational', 'graviton', and 'gravitational potential Φ_i', respectively in the QED section of electromagnetic field quantization. The field interaction section also needs the same insignificant corrections.

Thus, QGD becomes a new section of the quantum field theory describing the gravitational interaction. In a narrow sense, it is the quantum theory of gravitational field interaction with fermions (spinor gravidynamics).

The model representing two interacting relativistic fields serves as the basis for the modern QGD formulation. The gravitational field is characterized by the real 4-vector potential $\Phi_i(x)$ (i=0,1,2,3, x is a space-time point). The fermion field is described by a complex Dirac spinor ψ.

The interaction Lagrangian of QGD is

$$L(x) = m\overline{\psi}(x)\gamma^i\psi(x)\Phi_i(x) = j^i\Phi_i(x)$$, (7)

where m is the fermion mass, the line over ψ means Dirac's conjugation, γ^i are Dirac's matrices, and $j^i(x)$ is the 4-vector of the fermion current density. The mass m plays the role of interaction constant.

Conclusion: The gravitational frequency shift can be considered, on the one hand, as the first observed effect of QGD and, on the other hand, as the confirmation of RGD. But what is particularly important is that the QGD construction removes the principal difficulty on the way to the creation of a united theory for all of the fundamental interactions (SuperGUT) [2].

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