Superfluid Quantum Space, Einstein's Principle of Equivalence, and Bohr's Complementary Principle

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Abstract

Einstein's equivalence of inertial mass and gravitational mass is precisely measured. The common understanding is that inertial mass and gravitational mass are two different masses that are equal. Extension of the energy-mass equivalence principle on the superfluid quantum space is showing that inertial mass and gravitational mass of a given physical object have the same physical origin in the diminished energy density of superfluid quantum space in the centre of a given physical object. Particle motion in superfluid quantum space creates the wave of quantum space. Particles and waves are inseparable together.

1. Introduction

In recent decades, we have in physics a new perspective where universal space is understood as a superfluid vacuum named also superfluid quantum space (SQS) [1,2,3,4]. Space is a type of energy and we suppose that the energy density of space is related to the mass of a given physical object. In General relativity (GR), mass is curving space. In our model mass diminishes the energy density of space. The more space is curved in GR, the less is the energy density of space in our model. In general, the mathematical geometrical approach is upgraded with the physical approach of variable energy density. We extended the mass-energy equivalence principle to the universal space. Superfluid quantum space is the physical origin of the universal space. In the centre of a given stellar object, the energy density of SQS diminishes exactly for the amount of its mass m and its corresponding energy E:

$$\rho_{cE} = \rho_{PE} - \frac{mc^2}{V} \quad (1),$$

where ρ_{cE} is the energy density in the center of the stellar object, ρ_{PE} is Planck energy density, and V is the volume of the given stellar object [4]. When we rearrange equation (1), we get:

$$E = mc^2 = (\rho_{PE} - \rho_{cE})V \quad (2).$$

Equation (2) shows that the energy E of a given physical object is in equilibrium with the energy density of SQS. The energy density of SQS in the centre of a given physical object is diminished exactly for the value of its energy E. Eq. (2) is the extension of the mass-energy equivalence principle on the universal superfluid quantum space.

2. SQS model and physical origin of the Einstein's principle of equivalence

In GR a given physical object is curving the space. In our model of SQS, a given physical model is diminishing the energy density of space. The advantage of the SQS model is that it is valid from the size of the proton to the size of a black hole. The diminished energy density of SQS in the centre of a given physical object is causing the pressure of the outer SQS towards the centre of the object. This difference between the SQS pressure is the physical origin of the inertial mass and of the gravitational mass (see figure 1) as follows in Eq. (3):

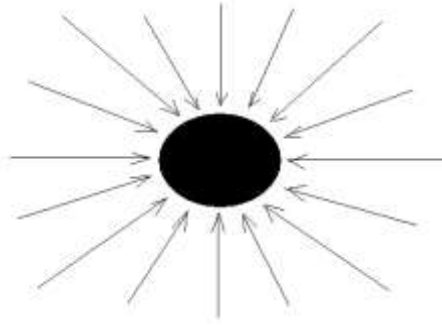$$m_i = m_g = \frac{(\rho_{PE} - \rho_{cE})V}{c^2} \quad (3). [5]$$

Figure 1: Physical origin of inertial mass and of gravitational mass

Rest mass m_0 of a given physical object is not its inertial mass. They have the same value ($m_0 \approx m_i$), but their physical origin is different. Rest mass is the amount of the incorporated energy E incorporated in the given physical object according to the Eq. (4):

$$m_0 = \frac{E}{c^2} \quad (4)$$

Rest mass ρ_0 is not the inertial mass ρ_i. Internal mass is the outcome of the relation of rest mass with the medium of SQS in which it exists. In special relativity, the relativistic mass is given by the Eq. (5):

$$m = \gamma m_0 \quad (5),$$

where γ is the Lorentz factor. A given physical object when accelerated to a high velocity will interact with the energy of SQS and absorb some of its energy. This is its kinetic energy that when a moving physical object is stopped by a barrier turns into light and heat. For the moving object the equation of minimal energy density in its centre is the following:

$$\rho_{cE} = \rho_{PE} - \frac{\gamma m_0 c^2}{V} \quad (6).$$

With the increase of the physical object velocity, the Lorentz factor is increasing too. Rearranging Eq. (6), we calculate the Lorentz factor as follows:

$$\gamma = \frac{(\Delta\rho_E)V}{m_0 c^2} \quad (7),$$

where $\Delta\rho_E = \rho_{PE} - \rho_{cE}$ is the relativistic delta energy density of the moving object. The higher the velocity of the physical object, the bigger the relativistic delta energy density and the bigger the value of the Lorentz factor. Equation (7) shows that the Lorentz factor depends on the relativistic delta energy density $\Delta\rho_E$ of the moving object [5]. The mathematical formalism above is observer-invariant. It is valid for all observers regardless of their position or velocity. Relativistic mass is the pure technicality of a moving object's interaction with the SQS.

Let's have a spaceship on the Earth's surface. The weight of a given object in the spaceship is defined by the diminished energy density of SQS on the Earth's surface. When the spaceship is accelerating in the intergalactic space the weight of the given object will be the same when the energy density of SQS because of spaceship acceleration will reach the same value as on the Earth's surface. In the described case, the variable energy density of SQS is the physical origin of Einstein's principle of equivalence, see figure 2.
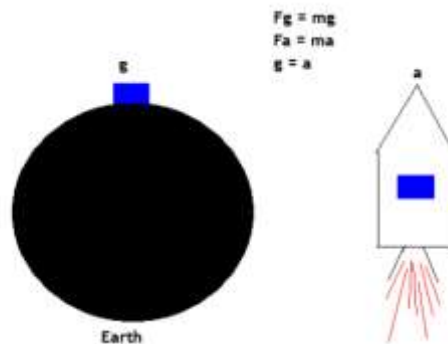

Figure 2: Einstein's principle of equivalence

Also, the relative rate of cocks is a pure technicality of the variable energy density of SQS. Clocks have a maximum rate in the intergalactic space where the energy density of SQS is at the maximum and a minimal rate in the black holes where the energy density of SQS is at the minimum. In all different inertial systems clocks run at the same rate for all observers; because their rate depends only on the variable energy density of SQS. As a relativistic mass, the relative rate of clocks also is observer-invariant. Einstein's idea that clocks run differently for "inner observer" and "outer observer" is not real. A clock on the train station and a clock located on the passing train have different rates that are valid for the observer on the train and for the observer on the train station. The relative rate of clocks is not some phenomenon that depends on the position of the observer, it depends only on the variable energy density of SQS. GPS system has proved that clocks on the satellites and clocks on the Earth's surface run at the same rate for all observers. Otherwise, GPS synchronization of clocks would not be possible [5].

3. SQS model and Bohr complementary principle

SQS model is confirming Bohr's complementarity principle in the sense that particle and wave are two aspects of the same phenomenon [6]. For example, when an electron is moving through the SQS it also creates a wave of SQS. In our model, the interference pattern in the double-slit experiment where single electrons are passing the upper slit is the result of a pure technicality of the interaction between moving electrons and SQS which produces waves passing through the down slit, see figure 3.
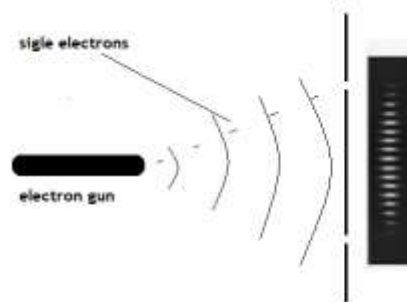
Figure 3: Double-slit experiment, where waves of SQS
created by the electrons are moving through the down slit

Considering that elementary particles exist as an energy structure of SQS is in our view the right direction for physics progress. "Empty space" without physical properties in which elementary particles move was a 20th-century mistake that needs to be recognized and abolished. It seems that Ervin Schrodinger's view was the most appropriate: "What we observe as material bodies and forces are nothing but shapes and variations in the structure of space" [7].

4. Conclusions

In Einstein's work, the equivalence of the inertial mass and of the gravitational mass bridged the special and general relativity. However, their origin has remained unknown because the model of space-time curvature is a geometrization of gravity where the physical cause of gravity force is not known. With the introduction of the variable energy density of SQS, we get the physical model of the equivalence of inertial and gravitational mass. With the introduction of the SQS as the fundamental arena of the universe, Bohr's complementary principle becomes obvious. The motion of a particle that is an energy structure of SQS creates the wave of SQS. Wave and particle are intrinsically both manifestations of SQS.

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