Low-energy quantum gravity: new challenges for an experiment and observation

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Abstract

Some new challenges for an experiment and observation, which are consequences of the model of low-energy quantum gravity by the author, are considered here. In particular, the property of asymptotic freedom of this model leads to the unexpected consequence: if a black hole arises due to a collapse of a matter with some characteristic mass of particles, its full mass should be restricted from the bottom. For usual baryonic matter, this limit of mass is of the order $10^7 M_\odot$.

During a few last decades, a verification of general relativity was almost a synonym for any experimental work in gravity. With enviable constancy this theory was recognized again and again as a favorite one among others, without any inconsistences with observations. But any theory should have its own borders of applicability. I think that we saw them for general relativity only in 1998, when Anderson's team reports about the Pioneer anomaly [1]; this effect is obviously not embedded in a frame of general relativity. In 2002, Nesvizhevsky's team reported about discovery of quantum states of ultra-cold neutrons in the Earth's gravitational field [2]. Observed energies of levels have the order of 10^{-12} eV. It means that energies of irradiated gravitons are of 40 orders lesser than the Planck energy. It is an absolutely unexpected scale for quantum gravity, but many prefer to think that this result is not connected with quantum gravity! The discovery of dimming of remote supernovae 1a in 1998 [3, 4] led to an introduction into physics of some new component - "dark energy", which is unknown from any laboratory experiment. It is very intriguing for me that a majority of people trust in this explanation of the observational peculiarity of the Hubble diagram; for me, it is simpler to doubt in the present cosmological paradigm and in applicability of general relativity for very big distances and time intervals. Another problem, the one of missing mass or "dark matter" for galaxies, is much longer standing. And there is not any warranty, too, that general relativity is true on the galactic scale.

I would like to pay your attention here on new challenges for an experiment and observation which are consequences of my model of low-energy quantum gravity [5]. In this model, quantum gravity is considered as a very-low-energy phenomenon: the average graviton energy is of the order of 10^{-3} eV. There are the following main problems.

1. *A verification of the redshift mechanism of this model.* The redshift is caused by forehead collisions with gravitons in this model. To verify this conjecture, the laser experiment may be performed on the Earth [6, 5]. A price of this question is very high: it would be possible to check indirectly and the conjecture about an expansion of the Universe.

2. *The Pioneer anomaly [1].* In the model, this anomaly is analogical to the redshift for photons. There exist plans of further investigation of this effect [7], and I would like only to say that if my explanation is true then some peculiarities should take place: the best parameter of the anomalous acceleration should be the angle between a velocity of the probe and its radius-vector (it means that the effect may change its sign); a periodic contribution should exist due to an anomalous acceleration of the Earth [8].

This deceleration of massive bodies by the graviton background may lead to an additional relative acceleration of bodies. Perhaps, namely the fact serves as a cause of successes of MOND by M. Milgrom in explanation of flat rotation curves of galaxies [9]. In MOND, when a body acceleration gets the threshold value of $\sim Hc$, one introduces by hand the growth of interaction; but this value characterizes the Pioneer anomaly in my model. Another possible origin of flat rotation curves in this model may be the screening of internal parts of a galaxy with its external parts, that will lead to a relative magnification of attraction of a periphery to the center.

3. *A multivalued character of the Hubble diagram.* The Hubble diagram is a multivalued function in this model [10]. It is difficult to verify this

prediction, because GRBs are not good cosmological candles, and supernovae 1a are not observable by big enough redshifts.

4. *The problem of existence of black holes.* The accepted mechanism of gravity in the model [5] leads to the consequence that a black hole should have an essentially bigger gravitational mass than an inertial one (approximately of 1000 times). There are the two variants: a) the equivalence principle is valid, then black holes cannot exist in the nature (in this case, super massive compact objects at centers of galaxies should have another nature); b) the equivalence principle is not valid for black holes which exist in the nature. In the second case, black holes should aim to the dynamical center of a galaxy with a huge acceleration due to the difference of gravitational and inertial masses. The objects known as black holes correspond to this scenario.

Additionally, the property of asymptotic freedom of this model [11] leads to the unexpected consequence: if a black hole arises due to a collapse of a matter with some characteristic mass of particles, its full mass should be restricted from the bottom. For example, in a case of collapsing usual baryonic matter one may accept that a particle mass is equal to the proton mass m_p. Big deviations from general relativity should take place by the minimum radius of the object: $r_{min} \sim < \sigma >^{1/2} N^{1/3}$, where $< \sigma >$ is an average cross-section of an interaction of a particle with a graviton, N is a full number of particles. We can compute the ratio r_g/r_{min}, where $r_g = 2Gm/c^2$ is a gravitational radius of the object:

$$r_g/r_{min} \sim (m/m_0)^{2/3},$$

where $m_0 = m_p(< \sigma >^{1/2} /r_{gp})^{3/2}$, and r_{gp} is a formally introduced gravitational radius of proton. The rough estimate for m_0 is: $m_0 \sim 10^7 M_\odot$. It is necessary to have $r_g/r_{min} > 1$, or $m/m_0 > 1$.

For another mass of particles of collapsing object, it is easy to re-calculate this bottom limit of the mass; because $m_0 \sim m_p^{1/4}$, we shall have by some new mass of particles $m' : m_0(m') = m_0(m_p)(m'/m_p)^{1/4}$.

5. *Gravitational asymptotic freedom.* An unalienable property of this model is asymptotic freedom at small distances [11]. The range of non-universal transition to asymptotic freedom for protons is between $10^{-11} - 10^{-13}$ meter, and for electrons it is between $10^{-13} - 10^{-15}$ meter. Big efforts were undertaken recently to detect micron-scale deviations from Newtonian gravity (for example, see [12, 13]), but this new needed range is very far from the investigated limit.

6. *Galaxy/quasar number counts.* Given only the luminosity distance and a geometrical one as functions of a redshift in this model, theoretical predictions for galaxy/quasar number counts may be found [14]. But the result depends on a chosen kind of the luminosity function and a theoretical model of quasar activity.

6. *A violation of the postulate about constancy of the velocity of light.* Due to a non-zero duration of an interaction of photons with gravitons, this postulate should be violated in the considered model if we consider very big distances. This theoretical problem is now open. If by attempts to build a model of quantum gravity starting from general relativity the small parameter to describe violations of the postulate is the ratio E/E_{Pl}, where E is an energy of a photon, and E_{Pl} is the Planck energy [15], in this model we should consider the ratio ε/E as such the small parameter, where ε is an energy of a graviton. A duration of one act of interaction would be estimated on a base of the uncertainties relation, and one might find a photon delay on its way using the lows of conservation of an energy and a momentum. I think that a dispersion of time-in-flight should depend on the photon energy (it should rise when E decreases). Any efforts to observe or to limit the Lorenz violation (similar to [16]) are very useful to clarify this question.

7. *A connection of the two backgrounds.* The graviton background should interact with the cosmic microwave one in this model. Perhaps, one of consequences of this interaction would be observed due to an existence of advanced technics and devices for microwave radiation measurements: any source of gravitational waves of general relativity should modulate the first background that will lead to the similar *temporal* modulation of CMB on expected frequencies of the gravitational waves. The important characteristic feature of namely this connection exists: when the modulated signal arrives to an observer from the source direction, this modulation should appear from the opposite direction, too. This proposal does not take into account a possibility of fast relaxation of any disturbance in such the dynamical substance as the background of super-strong interacting gravitons of this model. The theoretical problem of dissipation of energy of gravitational waves on their way in such the graviton background is open, too.

In this model, one does not need any dark energy or an expansion of the Universe to explain main observational facts. But there are many open problems, some of them are discussed above, which should be further investigated.

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