May gravitons be super-strong interacting particles?

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Abstract

A scheme, in which gravitons are super-strong interacting, is described. The graviton background with the Planckian spectrum and a small effective temperature is considered as a reservoir of gravitons. A cross-section of interaction of a graviton with any particle is assumed to be a bilinear function of its energies. Any pair of bodies are attracting not due to an exchange with its own gravitons, but due to a pressure of external gravitons of this background. A graviton pairing is necessary to obtain classical gravity. Any divergencies are not possible in such the model because of natural smooth cut-offs of the graviton spectrum from both sides. Some cosmological consequences of this scheme are discussed, too. Also it is shown here that the main conjecture of this approach may be verified at present on the Earth.

1 Introduction

What is a quantum mechanism of gravity? To answer this question, it is necessary to keep in mind a few different circumstances. A commonly accepted hypothesis, that an exchange with gravitons, which are radiated by bodies itself, causes classical gravity, is not a single possible one - gravitons

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might belong to an external sea of particles which exists independently of attracting bodies. A coupling constant of quantum gravitational interaction would differ from the Newton constant and may depend on energies of interacting particles. A geometrical language for short distances may not be adequate to describe quantum gravity. Perhaps, on the present stage when we know so a little about this mechanism, it would be better to consider a problem of its searching as a separate one. Some known effects which are not usually connected with gravity may be involved in a circle of interests of researchers by considerations of possible mechanisms. At first, it concerns cosmological effects which manifest themselves only on huge distances and during big times.

There are some facts beyond cosmology, which should be taken into account in this search, too. The Pioneer 10 anomaly [1] is one of them. Another fact is an observation of discrete energy states of neutrons in the Earth's gravitational field by Nesvizhevsky et al. [2]. In this remarkable experiment we see the huge difference - about 40 orders - between observed state energies $\sim 10^{-12}$ eV and the Planck energy of $\sim 10^{19}$ GeV which is expected from dimension reasonings as a threshold of any quantum gravity effect. The long known contradiction between the general relativity and quantum mechanics in descriptions of a microparticle motion is the third fact: if in one theory all particles should move on geodesics, in another they cannot move on definite trajectories. Maybe, a cause of this contradiction is that both theories do not take into account influences of single gravitons on a microparticle; then small graviton energies in a future theory are appeared to be more appropriate than the Planchian ones. A possible compositeness [3] of the fundamental fermions - electrons, neutrinos, quarks etc - should be taken into account, too. Components of these composite fermions would be bounded with a quantum gravitational interaction which is not similar to ordinary gravity.

The main features of a quantum model of classical gravity and its cosmological consequences are described here. The model is based on the conjecture about an existence of the background of super-strong interacting gravitons.

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2 A gravitational attraction due to the background

The important features of this model are the following ones (for more details, see [4, 5]).

• The graviton background has the Planckian spectrum and the same temperature T as CMB.

• The graviton background is in a state of dynamical equilibrium: it is cooled via self-interactions of gravitons and formation of virtual massive gravitons which may be dark matter particles, and is heated up via interactions with other radiations [6].

• A cross-section of interaction $\sigma(E, \epsilon)$ of a graviton with any particle is a bilinear function of its energies: $\sigma(E, \epsilon) = D \cdot E \cdot \epsilon$, where D is some new dimensional constant, E is a particle's energy, ϵ is a graviton's energy. The estimate of D is: $D \sim 10^{-27} m^2/eV^2$, i.e. gravitons are super-strong interacting particles.

• Due to a pressure of single gravitons, there act equal attractive and repulsive forces of three order greater than the Newtonian force between any two bodies, but a net force is equal to zero.

• To ensure Newtonian attraction, a pairing of single gravitons of running flux is necessary, and such pairs should be destructed by collisions with a body. A nature of this pairing remains unknown. If this pairs have spin 2, then single gravitons may have spin 1. Only two modes of spin-2 particles may exist in the model.

• Given this pairing, the Newton constant G is equal to:

$$G \equiv \frac{2}{3} \cdot \frac{D^2 c(kT)^6}{\pi^3 \hbar^3} \cdot I_2,$$

where k is the Boltzmann constant, $I_2 = 2.3184 \cdot 10^{-6}$.

• In the case of interaction of gravitons with big bodies in the aggregate, it is impossible to have Newton's law. One needs an "atomic structure" of matter to get this law.

• For proton-mass particles, the equivalence principle should be broken at distances $\sim 10^{-11}$ m, if the model is true. It means that at shorter distances gravity cannot be described alone, without other known interactions. It is also the limit to apply a geometrical language in gravity.

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3 Cosmological consequences of the model

Such the mechanism of gravity should have the following cosmological consequences [7, 4]:

• A quantum interaction of photons with the graviton background would lead to redshifts of remote objects; the Hubble constant H is equal in this model to: $H = \frac{1}{2\pi} D \cdot \bar{\epsilon} \cdot (\sigma T^4)$, where $\bar{\epsilon}$ is an average graviton energy, σ is the Stephan-Boltzmann constant. Redshifts are caused by forehead collisions with gravitons.

• The Hubble constant is connected in this approach with the Newton one as:

$$H = (G \frac{45}{32\pi^5} \frac{\sigma T^4 I_4^2}{c^3 I_2})^{1/2} = 3.026 \cdot 10^{-18} s^{-1},$$

where $I_4 = 24.866$.

• Due to non-forehead collisions with gravitons, an additional relaxation of any photonic flux leads to the luminosity distance D_L :

$$D_L = a^{-1} \ln(1 + z) \cdot (1 + z)^{(1+b)/2},$$

where $a = H/c$, z is a redshift, and the relaxation factor b is equal to [8]: $b = 3/2 + 2/\pi = 2.137$. See a comparison of this function with observations of [9] in my paper [10].

• Any light radiation spectrum will be deformed due to the quantum nature of red-shifting process. A theory of this effect does not exist today. But it may be checked experimentally in a laser experiment (see the next section).

• Any massive objects, moving relative to the background, should be decelerated by the background. A body's acceleration w by a non-zero velocity v relative to the background is equal to: $w = -ac^2(1 - v^2/c^2)$, and has by small velocities the same order Hc as an anomalous acceleration of Pioneer 10 [1].

• An existence of black holes contradicts to Einstein's equivalence principle in a frame of this model [4].

4 How to verify the main conjecture of this approach

I would like to show here a full realizability at present time of verifying my basic conjecture about the quantum gravitational nature of redshifts in a

ground-based laser experiment. Of course, many details of this precision experiment will be in full authority of experimentalists.

It was not clear in 1995 how big is a temperature of the graviton background, and my proposal [11] to verify the conjecture about the described local quantum character of redshifts turned out to be very rigid: a laser with instability of $\sim 10^{-17}$ hasn't appeared after 9 years. But if $T = 2.7K$, the satellite of main laser line of frequency ν after passing the delay line will be red-shifted at $\sim 10^{-3}$ eV/h and its position will be fixed, but, due to the quantum nature of shifting process, the ratio of its intensity to main line's intensity should have the order:

$$\sim \frac{h\nu}{\bar{\epsilon}} \frac{H}{c} l,$$

where l is a path of laser photons in a vacuum tube of delay line. It gives us a possibility to plan a laser-based experiment to verify the basic conjecture of this approach with much softer demands to the equipment. An instability of a laser of a power P must be only $\ll 10^{-3}$ if a photon energy is of $\sim 1 \ eV$. If one compares intensities of the red-shifted satellite at the very beginning of the path l and after it, and uses a single photon counter to measure the ones (when q is a quantum output of a cathode of the used photomultiplier, N_n is a frequency of its noise pulses, and n is a desired ratio of a signal to noise's standard deviation), then an evaluated time duration t of collecting data would have the order:

$$t = \frac{\bar{\epsilon}^2 c^2}{H^2} \frac{n^2 N_n}{q^2 P^2 l^2}.$$

Assuming $n = 10$, $N_n = 10^3 \ s^{-1}$, $q = 0.3$, $P = 300 \ W$, $l = 100 \ m$, we get: $t \sim 4$ days, that is acceptable for the experiment of such the potential importance.

5   Conclusion

The described model of Le Sage's kind has not an analogue in present-day physics of particles. If this mechanism is realized in the nature, both the general relativity and quantum mechanics should be modified. The indirectly observed objects in centers of galaxies, which are known now as black holes, should have another nature, too. Gravity at short distances, which are

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meantime much bigger than the Planck length, needs to be described only in some unified manner.

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