Original Research Article

ON THE GRAVITATIONAL SHIELDING PHENOMENON

It is shown that on the basis of previously developed phenomenological ideas about the nature of gravity as a consequence of "Casimir polarization" of electromagnetic component of the physical vacuum ("EM vacuum") in the vicinity of any material objects, which suggests the existence of shielding of gravitational interactions, one can understand the phenomenon of change of the gravitational acceleration during the total solar eclipse (Allais effect).

Keywords: Allais effect, variations of vertical gravitational acceleration, Casimir polarization of the EM vacuum, shielding of the gravitational interactions

1. INTRODUCTION

One of the debatable issues of gravity is the idea of shielding of the gravitational interactions. This problem dates back to the experiments of M. Allais [1], who discovered sharp changes in the plane of Foucault's pendulum during the total solar eclipse on June 30, 1954, which could be attributed to the termination of the action of forces due to the influence of the Sun on the pendulum oscillations. Subsequent studies of this phenomenon have established notable decrease of the normal to the Earth's surface component g_n of the gravitational acceleration during a number of total and partial solar eclipses. The character of the detected changes of g_n was established in [2] while performing measurements during the total solar eclipse on March 9, 1997 in China (Moho, Helongjiang province) using a very high-accuracy LaCoste-Romberg gravimeter, providing measuring the variations of vertical gravitational acceleration with a high precision of (2-3) μgal or (2-3)$\cdot 10^{-8}$ m/s^2. The most significant changes of g_n, manifested in the decrease of g_n by (5-7) μgal, were recorded at the initial and final stages of the total eclipse during the time intervals (~ 50 min) of intersection of the Moon disc with the external regions of the solar corona projection. Moreover, in the period of partial covering of the solar disc by the Moon, the projection g_n recovers up to the initial value; however, the average value of this projection during the total covering of the solar disc by the Moon (during ~ 2-3 min) turns out to be somewhat less, by the quantity ~1 μgal, than the initial average value of the component g_n. In addition, the

recorded in various experiments values of the Allais effect, the anomalies in the changes of g_n during solar eclipses, turn out to be dependent not only on the magnitude of the solar eclipse, defined as the part of the Sun's diameter, darkened by the Moon, but also on the geographical coordinates of the areas where the attempts were made to detect this effect [3, 4].

The first attempts to understand the recorded reducing of the component g_n of the gravitational acceleration during solar eclipses were linked to Quirino Majorana's hypothesis of gravitational shielding or attenuation ("absorption") of gravity by material medium, separating the gravitationally interacting objects, based on the experimental studies which he carried out in the 30-ies of the last century [5]. However, the subsequent experiments led to doubts concerning the experimental results of Majorana. It was suggested that the gravitational shielding cannot be the cause of the discussed gravity anomalies recorded in solar eclipses [3, 6]. This conclusion also follows from the general theory of relativity. A number of papers discussed a possible connection between these gravity anomalies with the purely atmospheric phenomena caused by a sudden decrease in temperature in the upper layers of atmosphere during the overlapping of the solar corona and the Moon's disk and the corresponding abrupt changes of atmospheric pressure [3, 7]. It was believed that the significant movement of air masses initiated by the specified decrease of temperature should be considered as one of the possible causes of the considered anomalies.

The new interest in the Allais effect research was associated with the appearance of the paper work [8]. The variations of the apparent vertical direction of the gravity field were measured with horizontal gravimeters acting as tilt meters during the total solar eclipse in Turkey in March 29, 2006. Three separated locations within the path of totality were chosen for observations, two spaced (~ 50 km) apart along the center line, and one off (~ 60 km) the center line. Aperiodic oscillations in tilt were recorded at the two locations on the center line. These may be related to the eclipse phenomenon. The average tilt amplitude deviation during the eclipse over all locations and in all directions was 150 nrad, which can be regarded as a mean upper limit for the eclipse related changes in the tilt.

Apparently, even more intriguing was associated with the observation of correlated behavior of two light torsion balances (TBs) and a paraconical pendulum in separate locations (in Ukraine and Romania, 440 km away) during the solar eclipse of January 26th 2009 [9], that was not visible at those locations but only in the Indian Ocean. Notably, that a significant correlation between the reactions of the pendulum and the TBs was valid only in

the time interval when the lunar shadow was passing over the Earth. Outside this time interval (~ 5 h), the correlation was absent. This fact is another strong argument in favor of the conclusion that the solar eclipse was the cause of the correlated variations. At the same time, the authors [9] note that the anomalies can not be found understanding from the point of view of modern physics.

Summarizing the available information, we can conclude that to date the questions about the nature of the Allais phenomenon, the reasons for differences in its intensity up to impossibility of recording the anomalies in g_n during some solar eclipses remain unresolved. The author believes that the indicated issues should be considered in conjunction with the known general problems of gravity, including the very mystery of its essence and the origin of anomalously low value of gravitational constant in comparison with the constants of nuclear (strong and weak) and electromagnetic interactions, as was indicated by Feynman more than 50 years ago [10].

In this note we show that the Allais phenomenon can be understood on the basis of ideas about the nature of gravity, developed in [11, 12]. In that paper we demonstrated that gravity can be seen as a consequence of "Casimir polarization" of electromagnetic component of the physical vacuum ("EM vacuum") in the vicinity of any material object in the Universe. According to [11, 13], the EM vacuum is the basic environment of the Universe, a kind of modern "ether". The density of the vacuum energy EM calculated on the basis developed in [13] ideas about the dynamics of the Universe, is $\varepsilon_V^e \approx 1.5 \cdot 10^{-8}$ erg/cm^3. [11] This value is in an agreement with the value of $\varepsilon_V^{\exp} \approx 1.14 \cdot 10^{-8}$ erg/cm^3 [13] which was obtained on the base of the known estimates for the total ε_{tot} energy density of the Universe $\varepsilon_{tot} \approx 0.9 \cdot 10^{-8}$ erg/cm^3. It should be pointed out that the energy density ε_V^e exceeds the value ε_{tot}, because, according to [13], the other two components of the total energy density, namely, the so-called baryonic component and component of "dark matter" are negative. The latter indicates that all material objects are associated with the EM vacuum. In particular, the binding energy $\overline{E}_0$ of a particle of mass m_0 with EM vacuum is determined by a known ratio $\overline{E}_0 = -m_0 c^2$ [13], where c is the light velocity in EM vacuum. At the same time, all energies are measured from zero, which is associated with zero rest mass of EM quanta. The energy quanta E_ω of electromagnetic radiation with angular frequency ω is positive and equal to $E_\omega = \hbar\omega$, where $\hbar$ is the Planck's constant.

Casimir force arises from the action of energy-containing EM vacuum on the material body treated as a set of distributed charges and currents. This effect is determined by conjugation of the electric field components of the EM vacuum on both sides ("external" and "internal") of the material object's boundary with vacuum.

In the framework of such ideas, gravity is the mutual attraction of two masses that occurs due to the overlapping fields of the Casimir polarization of the EM vacuum in their neighborhood, while the attractive exposure to each of these masses of all the mass of the Universe. The latter corresponds to the Mach's idea about the influence of all the physical bodies of the Universe on each individual mass [15]. Gravitational interaction of any pair of bodies is weakened if there appears between these bodies a third body which partially or completely screens these bodies from each other. In this case, the direct interaction between the original bodies does not disappear completely even when the visual connection between them is totally blocked. In the latter case, in accordance with the ideas of [9], the direct interaction between the original bodies has to manifest itself, nevertheless, in the general gravitational interaction of the considered 3 bodies, determining the state of the Casimir polarization of the near-surface regions of the 3rd body facing the original bodies, and the population of these regions by virtual photons under various spatial configurations of all three bodies. Therefore, direct Sun-Earth interaction is screened during the total solar eclipse. This interaction is carried out through the solar corona and the area with a high density of the solar wind, other masses, which directly interact with the Earth and the Sun. It is in this way that it is possible to understand the discussed in the literature effects of gravitational shielding, weakening of the gravitational interaction between two masses after the appearance a third body in the space between them.

2. THE GENESIS OF THE ALLAIS EFFECT

The introduction of this "gravity shielding" allows a qualitative understanding of the possible nature of the Allais effect. In accordance with the foregoing, the Moon's disc is a screen for direct interaction between the Earth's gravity with those parts of the mass of the Sun, its crown and its atmosphere not showing in the total solar eclipse, which are closed by the Moon. For this reason, already at the early stages of such screening, there begins to change dramatically − albeit on a relatively small ($\sim 10^{-5}$) value for the entire area covered by the solar eclipse − the strength of the Earth's interaction as a planet with the Sun, i.e., the "acceleration g_{ES} of free fall" of the Earth to the Sun, determining the centripetal acceleration

of the Earth as it moves in its orbit around the Sun, which is equal to $g_{ES} = GM_S / L_{ES}^2 = 5.9 \cdot 10^{-3}\,\text{m/s}^2 \approx 0.6 \cdot 10^{-3} g_n$. Here $G = 6.67 \cdot 10^{-8}\,\text{cm}^3/\text{g}\,\text{s}^2$ is the gravitation constant; $g_n = GM_E / R_E^2 = 9.8\,\text{m/s}^2$ is the gravitational acceleration on the Earth; $M_S = 1.99 \cdot 10^{33}\,\text{g}$ is the mass of the Sun; $M_E = 5.97 \cdot 10^{27}\,\text{g}$ is the mass of the Earth; $L_{ES} = 1.5 \cdot 10^{11}\,\text{m}$ is the distance from the Sun's center to the Earth's center; $R_E = 6.37 \cdot 10^{6}\,\text{m}$ is the radius of the Earth. The recorded in the experiment [2] maximum reductions δg_n of the value of g_n at the initial and final stages of total solar eclipse were about $5 \cdot 10^{-8}\,\text{m/s}^2$ and $7 \cdot 10^{-8}\,\text{m/s}^2$, respectively.

The very existence of centripetal acceleration g_{ES}, acting on any material body on the Earth, means that the reaction force of support occurring due to the pressure on the balance from a material body with the mass m, which is attracted to the center of the Earth, must exceed the weight of the body precisely by the quantity mg_{ES}. It is obvious that since the beginning of the solar eclipse for the territories where it takes place, with the beginning of the overlap by the Moon's disc of the outer atmosphere and corona of the Sun, the value of g_{ES} begins to decrease. To a smaller value of the centripetal acceleration of these territories with relatively small area, there must correspond more distant from the Sun trajectories, and it should initiate an "indentation", lowering the level of these territories with respect to the surrounding ones ("local earth low tide"). Naturally, such "indentation" must give rise to the obstructing it "ejecting" impacts from all the surrounding areas, for which the gravitational interaction with the Sun does not change. The result of these "ejecting" impacts should be local disturbances or some rearrangements of the lithosphere of the areas where a solar eclipse takes place, and related areas, bearing in mind the work [9], which lead to some redistribution of mass in the vertical sections of lithosphere and diminishing of gravity in these areas. This is achieved by these "ejecting impacts", resulting in the fact that the support reaction in weighing exceeds the force of normal pressure on the balance by the amount compensating the decrease of the centripetal acceleration g_{ES} (we are talking about the values of the order of $\sim 5 \cdot 10^{-8}\,\text{m/s}^2$) due to gravity shielding of the influence of a part of the Sun's mass on the Earth.

As shown by the experimental results of [2], the suddenly started transient processes of this kind end at the stage of the first overlap of the solar corona by the Moon's disc. Therefore, we can assume that in the next stage of the solar eclipse, until the complete overlap by the Moon's disk of the visible solar disk, the initiated rearrangements in the

lithosphere of the territories of the solar eclipse occur in a stationary mode, while providing the required variations in the mass distribution in the vertical sections of the lithosphere and the corresponding changes in the local value of the centripetal acceleration g_{ES}. It should be noted that the situation here is approaching a usual one, which is realized due to much more slowly changing tidal deformations under the influence of Moon and Sun's gravity, when the values of variations of the gravitational acceleration g_n can be much greater than the values recorded in the experiments [2].

The situation changes when the Moon's disc, shielding the Sun's gravitational influence on the Earth, begins to overlap again the solar corona, increasing the observed area of the surface of the Sun. The started increase in the values of centripetal acceleration g_{ES}, which correspond to the stationary orbits more close to the Sun, will initiate a reverse process of "raising" the level of the territory above the surrounding areas ("local earth tide"), and hence the natural reaction of the surrounding areas preventing such "uplifts" and initiating "indentation". Due to irreversibility of the lithosphere rearrangements occurring at the first phase of a total solar eclipse, at the second and final stage of the initiation of rearrangements in the lithosphere we should expect additional rearrangements and increasing of their total scale. It is with the latter circumstance that one can associate somewhat larger value of the recorded changes in the value of g_n at the finishing stages of a total solar eclipse [2]. It should be noted that these effects depend on many unknown factors, including the physical characteristics of the lithosphere in the area of the solar eclipse and the surrounding area. Therefore, it is difficult to discuss any quantitative comparison of the projected local terrestrial tides with lockable g_n changes. It should be also pointed out that the proposed shielding mechanism differs essentially from mechanisms considered in cosmology [16, 17], $f(R)$ gravity theory [18, 19], massive gravity theory [20, 21] and other theories which generalize Einstein's general relativity.

3. CONCLUDING REMARKS

The foregoing ideas about the genesis of the Allais phenomenon also allow understanding possible reasons for the observed differences in the recorded values of g_n during the observation of solar eclipses in different parts of the Earth, linking the observation results to the differences in the geological features of this or that region, including in adjacent areas where the solar eclipse is not visible. From this perspective, it would be interesting to conduct appropriate experiments during a total solar eclipse by several groups in several

regions that are different in their geological structure, and also in the ocean using the same measurement techniques and the same high-precision equipment. The results of experimental studies in the regions of ocean with different depths would allow finding out what depths may be affected by the initiated in a solar eclipse local disturbances or some rearrangements of the lithosphere, and to what extent the lability of the water areas is sufficient to exclude the recorded manifestations of the Allais phenomenon.

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