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Quantum Vacuum Energy and the Emergence of Gravity An Essay

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Abstract

Building on the work of others a novel idea is put forward regarding the possible mechanism of gravity as involving energy coupling down the energy gradient of a massive body. Free fall (acceleration) in a gravitational field is explained as arising from an interaction of the modified quantum vacuum energy in the vicinity of matter.

Key words: Gravity, quantum vacuum, zero-point energy, electromagnetic energy, inertia, acceleration, free fall, gravitational energy gradient, non-gravitational acceleration

1. Introduction

There has been a great deal of activity, both in terms of theoretical and experimental work exploring the possible link between quantum vacuum energy and gravity. Over the years quantum vacuum energy has become synonymous with zero-point energy (ZPE), and so this term will be used interchangeably throughout this paper. The nature of ZPE has been the subject of intense interest (Santos, 2012; Margan, nd (a&b); Rueda & Haisch, 2005; Puthoff, 2001). It was Sakharov (1967) who reached the conclusion that matter somehow induced certain changes in the quantum vacuum and that these changes might explain a number of phenomena including the Casimir effect. As time went on other workers conjectured and presented cogent arguments regarding the role of the quantum vacuum or ZPE in the emergence of gravity, inertia and indeed mass itself (Haisch et al., 1997; Rueda & Haisch, 2005). This pioneering work paved the way for Rueda, Haisch and Puthoff to propose a model in which the elementary entities making up atoms would interact with the zero-point field via a kind of resonance effect. Ultimately a model was proposed (Rueda & Haisch, 2005);

$$m_i = \left[\frac{V_0}{c^2}\int \eta(\omega)\frac{\hbar\omega^3}{2\pi^2 c^3}d\omega\right]$$

and

$$m_g = \left[\frac{V_0}{c^2}\int \eta(\omega)\frac{\hbar\omega^3}{2\pi^2 c^3}d\omega\right].$$

(Rueda & Haisch, 2005)

in which m_i and m_g are the inertial and gravitational masses, V_o the proper volume, $\eta(\omega)$ the resonance or coupling function, and the third term represents the spectral energy density expression. c is of course the speed of light, h (bar) is the reduced Planck's constant and ω is the characteristic frequency mode. In light of the weak equivalence principle the above equations were developed (Rueda & Haisch, 2005). Caligiuri and Musha (2014) provide a very lucid summary in the introduction to their paper regarding the development of the above model and continue on to discuss their ground breaking ideas regarding the role of the quantum vacuum and the emergence of gravity.

In this paper we focus on two important outcomes of Rueda and Haisch (2005); Haisch et al. (1997) and Puthoff's (2001) work; one relating to the idea of resonant coupling ($\eta(\omega)$) and the other the quantum vacuum spectral energy density h(bar)$\omega^3/2\pi^2c^3$ and their possible joint role in the emergence of gravity. We speculate the presence of mass causes a specific spectral signature to emerge from the ZPE and that this signature carries a matter-specific resonance energy ($\eta(\omega)$) which, along with the overall altered energy density ($h_{(bar)}\omega^3/2\pi^2c^3$), is the primary cause of so called 'gravitational attraction'.

We also suggest that all bodies may possibly interact with vacuum energy and couple (via a common resonant energy) to the ZPE even when not accelerated (i.e. 'stationary' or in uniform motion remote from gravitating bodies. See Caligiuri's (Caligiuri, 2014) proposal along similar lines regarding standing waves within mass). Consistent with the Rueda and Haisch (2005) hypothesis, in the case of non-gravitational acceleration (the application of a force), there is a ZPE asymmetry created, proportional to the force itself. On the other hand, with gravitational acceleration (Note 1), there is no such asymmetry (during free fall) and therefore no force, because while bodies are linked via a couple (the scalar component) they follow an energy gradient (vector component), both of which are present in the vicinity of the gravitating body. This state of affairs is theorized in general relativity (GR) as geodesic motion (Note 2), but GR is silent as to the cause.

2. The Quantum Vacuum (Zero-Point Energy)

There continues to be much debate over the nature and indeed the very existence of zero-point energy. Many researchers have conducted work and written extensively on the subject (Milonni, 1994; Santos, 2012; Margan, nd (a&b); Marshall & Santos, 1997; Sakharov, 1967; Caligiuri & Musha, 2014; Caligiuri & Sorli, 2014). It is a vast field and growing. There is a range of views regarding the amount of energy resident per unit volume of supposedly empty space. Densities up to 10^{113}J/m^3 have been calculated based on Planck units (the quantum calculations). In terms of cosmological observations (Margan, nd (a)) cites values in the order of $\approx 10^{-9}$J/m^3. This is very small indeed and the difference between the two has been referred to as the '120 orders of magnitude difference'. Its resolution has been a very big challenge for physics for many years.

In building upon the ideas in a recent paper (Tattersall, 2017) we take the view that the value of the zero-point energy in the absence of matter is near or close to zero on average. Its presence has been indicated by numerous Casimir experiments (Bordag et al., 2001; Rajalakshmi, 2004; Lambrecht & Reynaud, 2011). We suggest that the presence of matter causes a disturbance in the quantum vacuum energy balance via scattering phenomena (Lambrecht & Reynaud, 2011). Along similar lines suggested by Rueda and Haisch (2005) and Caligiuri and Musha (2014), we also propose that zero-point energy in its interaction with matter leads to the emergence of gravity as a residual and somewhat feeble 'force'. Therefore our proposal brings some new ideas to the table.

3. Disturbance of Zero-Point Energy in the Vicinity of Matter – Some Theoretical and Experimental Indications

The contributions of a number of other researchers have in the author's view led to breakthroughs in relation to how gravity might emerge from the interaction of mass and vacuum energy. The work of Caligiuri (2014), Caligiuri and Sorli (2014) and Caligiuri and Musha (2014) are of vital importance. It is this vital foundation as well as the work of Margan (nd (a&b)) that we recognize as playing an influential and beneficial role in the development of the ideas put forward in this paper.

We recently explored a possible mechanism for the emergence of an energy gradient in the vicinity of matter. We suggest that the presence of mass causes the local zero-point energy to be displaced from its equilibrium null balance (perhaps via some kind of scattering effect) to one where certain energies dominate. In so doing there exists an energy gradient in the vicinity of matter, which could possibly be theorized along the lines of that suggested by Caligiuri and Musha (2014). Past and more recent experiments (Rancourt, 2011; Rancourt & Tattersall, 2015; Neumann, 2017) all suggest that the energy field in the vicinity of test masses can be influenced by electromagnetic energy of various wavelengths, and the effects appear greater than the gravitational effect of light itself. This suggests that gravity has an electromagnetic component, however feeble. These experiments are yet to be repeated in other laboratories.

4. Gravitational Effect – Coupling in the Energy Gradient

Let us now consider two objects of dissimilar mass falling (accelerating) in a gravitational field (say that of earth). By virtue of the earths mass the two objects are falling in an already modified zero-point energy field. There is a significant energy gradient due to the scattering of the local quantum vacuum energy (zero point energy) caused by the massive gravitating body. Each of the falling objects also has its own ZPE-scatter energy content, the density and gradient of which are directly proportional to their individual masses. The spectral energy signature of the earth and each of the object masses is identical and so this is the source of the resonant coupling that exists between masses. In a sense, this is similar to the function ($\eta(\omega)$) described by Rueda and Haisch (2005).

We know from experience that both objects, if released at the same instant, will strike the ground at the same time as they will fall with the same acceleration. This is usually explained as due to the equivalence of gravitational and inertial mass. But it is speculated that there may be a deeper reason. In an already prepared quantum vacuum (arising from the presence of a very massive body, e.g. a planet), possessing the specific matter spectral signature (resonant spectrum, the key parameter of which is η(ω)) the falling object with the most mass has a greater overall density ($h_{(bar)}\omega^3/2\pi^2c^3$) of scattered zero-point energy associated with it and so it tends to move faster down the energy gradient created by the massive gravitating body. By the same token, the scattered zero-point energy of the more massive falling object has a greater coupling (η(ω)) with the local ZPE per unit length (due to its higher overall density of resonant component of the zero-point energy) of fall compared to that of the smaller object, so this tends to retard its movement. In contrast, the smaller object's mass has a lower overall density of scattered zero-point energy associated with it and so tends to move more slowly down the energy gradient created by the gravitating body. But on the other hand, the lower overall density ($h_{(bar)}\omega^3/2\pi^2c^3$) of the zero-point energy possessed by the smaller object leads to less coupling (η(ω)) per unit length of fall in the gradient so it is less retarded in its movement.

It is the ratio of resonant coupling intensity to relative energy change down the gradient that is the basis of constant acceleration in a given, so called gravitational field. While the coupling and spectral densities of small masses are both feeble, it is the much larger energy gradient of the 'gravitating' mass that dominates the acceleration of the smaller bodies in its vicinity. Therefore, to a point, small masses all appear to accelerate at the same rate in the vicinity of a given massive body. This is why neither the gravitational mass nor the inertial mass of falling bodies appear in acceleration formulae involving a given G [Note 2].

5. Conclusions

In everyday observations the gravitational acceleration of objects appears to be independent of the affected objects own mass, whereas in reality it may be due to the way in which components of the energy gradient of 'gravitating masses' interact with bodies in their vicinity. If, as suggested by many researchers, ZPE-matter interactions are responsible for gravitational and inertial effects, then a new area of research could emerge. Indeed this new idea may well bring into question both the principle of equivalence in a general sense, and the nature of gravity itself (see Caligiuri's (2014) discussion on the nature of G), which could be viewed as perhaps an emergent effect arising from the quantum vacuum. The principle of equivalence may only *appear* to hold true for those cases thus far studied in the observable universe. This has been discussed by Van Flandern (2008) at some length.

We suggest that most of the essential mathematical basis is already in place and all that is needed is further experimental evidence, possibly along the lines of that suggested in this paper, to elucidate the nature of the coupling itself, which appears to be perhaps the final 'unknown' quantity. This appears to be electromagnetic, albeit perhaps in a form that may require redefinition of our ideas regarding this type of energy. To that end the proposal by Rueda and Haisch (2005) that interactions between the quantum vacuum energies and fundamental atomic entities is the basis of gravity and inertia is thought to be highly relevant.

We also put forward an important idea relating to the behavior of the quantum vacuum in the presence of matter, suggesting that the null state (due to the self-cancelling quantum virtual activity) is disturbed once matter is present. We suggest this disturbance leads to the dominance of a real energy (quantum vacuum or zero-point energy), a component of which is a feeble energy signature from which gravity emerges, a view similar in many ways to those proposed by Puthoff (2001) and Haisch et al. (1997).

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Notes

Note 1. Acceleration (gravitational) referred to in this paper is that which is observed from a frame at rest relative to the gravitating body.

Note 2. Falling objects are weightless (sense no acceleration) due to the moment-to-moment energy exchange down the energy gradient during which relative changes in coupling energy and energy density create an illusion (on the part of the falling body) of stationary weightlessness. When this motion (geodesic in GR) is prevented an inertia reaction force emerges which manifests as weight (Rueda & Haisch, 2005).