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A Possible Explanation for the Vacuum Catastrophe

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Abstract

The discrepancy of 120 orders of magnitude between the observed energy density of the vacuum and that predicted from manipulations of quantum assumptions has been considered as the "worst prediction in physics". By employing abbreviated quantum "natural units" the predicted density is 2.9×10^{120} greater than the $\sim 10^{-9}$ J/m^3 estimated by current measurements. However a comparable order of magnitude discrepancy for energy, 6×10^{120}, emerges when the total calculated force within the universe is distributed across its width. The energy density within the vacuum should be $\sim 10^{111}$ J/m^3. Because the emergence of the total force value required the square of the cut off frequency for Zero Point Fluctuations, the discrepancy could be considered as an artifact of temporal sampling, that is, the implicit temporal increments from which the estimates were derived. The identity of the predicted vacuum energy density from counting modes and energy density from quantum theory and that obtained from Newtonian Force applied across the universe could be a considered example of $\sum n = n$, which is one condition for a holographic state.

Keywords

Vacuum Catastrophe; Energy Density of Vacuum; Quantum Field Theory; Total Force; Boundary Conditions

1. Introduction

According to Adler *et al.* [1] a very large energy density for the vacuum with concomitant gravitational effects is a natural prediction from quantum field theory. However the value for this discrepancy between current measurements and the quantitative estimates derived from the theory is $\sim 10^{120}$. The divergence between theory and measurement has been attributed to the prediction that every degree of freedom of the electromagnetic field has an associated zero point energy (ZPE) or ground state defined by $\hbar\acute{\omega}/2$ where $\acute{\omega}$ is the energy or frequency of the

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degree of freedom. A frequently employed "quantum approach" has been to reduce physical values to "natural units" whereby the resulting values become dimensionless.

Assuming the reasonable maximum energy for photons exhibits a Planck energy (Planck's constant expressed as eV·s) of about 10^{19} GeV, which is a value at which gravitational interaction is approximately the same magnitude as the electromagnetic interactions, the vacuum energy density according to Adler *et al.* [1] exhibits a threshold of $\rho = 8.4 \times 10^{76}\ f^{-4}$ where f is the reduced value in femtometers (Fermi) within four dimensional space. On the other hand, the estimated quantitative estimates of the mass density of the universe based upon visible stars is $\sim 10^{-28}$ kg/m^3 but when dark matter is considered the value could approach $\sim 10^{-26}$ kg/m^3. Hence the upper limit estimate for the vacuum density would be in femtometer units $\rho < 10^{-26}$ kg/m^3 = $2.9 \times 10^{-44}\ f^{-4}$.

The ratio of discrepancy between the predicted and the observed value is 2.9×10^{120}. Given the typical assumption of the current universe that the energy density is $\sim 10^{-9}$ J/m^3 this would indicate that the predicted ZPE would be $\sim 10^{111}$ J/m^3. The source of this "vacuum catastrophe" has been subject to several innovative explanations. Here, I present quantitative support that the manner in which total force of the universe from summed quanta (Planck's lengths) is distributed across the universe results in the same discrepancy for which there is a less contentious explanation.

2. Calculations

The estimated "total" energy of 2.2×10^{69} J [2] of the universe with a volume (assuming a sphere) of 8.4×10^{78} m^3 from an age of 4.2×10^{17} s, results in an energy density of $\sim 0.3 \times 10^{-9}$ J/m^3. This value converges with the product of the square of the velocity of light in a vacuum and the average density of 1 proton (1.27×10^{-27} kg/m^3) which is 15.03×10^{-11} Pa or 0.15×10^{-9} J/m^3. Similarly, the product of the Newtonian Gravitational Constant (6.67×10^{-11} m^3/kg·s^2) and [kg^2/m^4] where kg = 2.5×10^{52} kg and r = 1.26×10^{26} m, that is [(5.76×10^{104} kg^2)/(2.52×10^{104} m^4)], results in a density of 0.15×10^{-9} J/m^3.

However if we assumed the total mass of the universe is 2.4×10^{52} kg [2], the effective length is $8.8 \cdot 10^{26}$ m derived from 2R (where R, estimated from $f = 8\pi G c^{-2}$, is 4.4×10^{26} m, [3]), and the square of the Zwitterbewegung or cut-off frequency for the ZPF is 10.4×10^{86}/s^2 [4], the summed force is 220×10^{164} N. When multiplied by the current width or "length" of the universe from simple expansion (2.52×10^{26} m) the total force is 555×10^{190} J. When divided by the current volume, 8.4×10^{78} m^3, the volume energy density is 1.8×10^{111} J/m^3. The ratio of the difference between this predicted energy density and the estimated observed energy density of 0.3×10^{-9} J/m^3 is 6×10^{110}. This value is the same order of magnitude and within a factor of 2 of the coefficient from the discrepancy derived from the more complicated intricate mechanics employed by Adler *et al.* [1].

3. Conclusions and Implications

The marked congruence between the calculated value for total energy within the universe based upon treating the mass, adjusted distance and cut-off frequency for ZPE when spread across the universe and the energy derived from quantum assumptions that include gravity suggest the apparent "catastrophe" resulted from comparison of qualitatively different perspectives. Inclusion of ZPE frequencies which relate to Planck's Time into the calculation of total force results in an exaggerated value compared to that derived from concepts of Joules and implicitly the one second unit. If the application of this total force over distance to produce the "total" energy results in the same energy density as that from quantum estimations, then the identity indicates that the $\sum n = n$, where n is the basic unit. This condition has been considered by many as the major property of a hologram.

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