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The Cosmological Constant Problem and the Vacuum Energy Density

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Abstract

The cosmological constant problem or vacuum catastrophe is localized in the convergence between general relativity and quantum field theory, it is considered as a fundamental problem in modern physics. In this paper we describe a different point of view of this problem. We discuss problem could depend to different definition of the vacuum energy density.

Keywords: Vacuum catastrophe • Fundamental problem • Modern physics • Vacuum energy density

Introduction

Quantum field theory (QFT) which is fundamental in modern physics show zero-point energy in space, including in areas which are in another way 'void' (i.e. without radiation and matter). Maybe we could think these zero-point energy give a vast vacuum energy density. On the other hand it is expect to cause an increase of cosmological constant appearing in Einstein's field equation.

Description

Equations should be agreed with Newtonian theory in the limit for medium and small gravitational fields and small velocities, and this should be consonant also with the value of [1]. In fact, compare equation with observations show that is minuscule. Where the curvature of space-time, is the metric, G is the gravitational constant is the stress-energy tensor, and c is the speed of light [2].

R-Rg+Ag=8G (1)

The Friedmann equations are a set of equations in physical cosmology that govern the expansion of space in homogeneous and isotropic models of the universe based on setting the normalized spatial curvature,k, equal to zero according to the model when the substitutions are applied to the first of the Friedmann´s equations we find:general relativity [3]. There are two independent Friedmann equations. This equation usually has been understood as the vacuum energy density in gravitational theory, nevertheless, theoretical estimates the vacuum energy density in QFT exceed the observational measurement by at least 40 orders of magnitude. This contrast constitutes the cosmological constant problem [3].

Quantum electrodynamics is one of the principal components in the Standard Model, first, and most productive case of a working quantum field theory. We first remembrance that systems studied in non-relativistic quantum mechanics, spatial-temporal coordinates, energy and others are represented by operators in quantum electrodynamics [3].

One of the most simple quantum systems is the quantum harmonic oscillator. The ground state (vacuum state) of the quantum harmonic oscillator has zero point energy: universe. The effect of the vacuum energy appears in the first Friedmann equation, vacuum energy is expected to create the cosmological constant, and produce the expansion of the universe. In classical electromagnetism, electromagnetic fields have values E, and B in all space-time (Figure 1).

The energy density in the classical electromagnetism theory is: Vacuum energy is the background energy that exists in the universe. The effect of the vacuum energy appears in the first Friedmann equation, vacuum energy is expected to create the cosmological constant, and produce the expansion of the universe. In the quantization, quantum operators take the place of classical fields, the ground state the vacuum state of QED.

Future Prospective

Whole zero-point energy of the quantum electrodynamic theory can be expressed by: It is easy to see, modern physics could enter between electroweak scales and Planck scales but if the alternations are still out of the framework of quantum field theory, we could admit vacuum energy can be expressed. Where wave-numbers are are frequencies of a continuum of (plane-wave) modes. The infinite delta-function can be regularized introducing a cube of volume. This volumes represent the standard 'box-quantization' process for the electromagnetic field in which an artificial 'quantization volume' is used to create an equivalence with a harmonic quantum oscillator field mode. Energy density in this approximation can be extract from the zero-point energy of harmonic quantum oscillator mode [4].

Where the wave vector k now refers to the so-called normal modes (of the electromagnetic field) which are compatible with the boundary conditions provided by the box volume. The right hand side of the equation follows from the left hand side in the limit where the energy density does not depend on the 'box quantization' volume. If we imagine that the QFT framework is valid to the Planck energy: It is easy to see, modern physics could enter between electroweak scales and Planck scales but if the alternations are still out of the framework of quantum field theory, we could admit vacuum energy can be expressed (using Planck slower and faster than the speed of light. In the current expansion model FWR light emitted from the Hubble´s radius will reach us in a finite amount of time, this is observable Hubble´s radius will be our universe radius. On the other hand we continue using the vacuum state of QED but we use zero point energy of three-dimensional harmonic oscillators in our calculus because ground state is in a three-dimensional space [4]. First we calculate vacuum energy of one line, vacuum energy along R is the sum of vacuum states of three-dimensional we compare vacuum states sum along R with continuous dimensional wave equation. (We calculate it in two different ways and we take wave properties of the QED vacuum).We need

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$$H_0^{\,2} = \frac{8\pi G\rho}{3} + \frac{\Lambda}{3} + \frac{kc^2}{a^2} \quad (3)$$

Where:

$$\rho_m + \rho_r = \rho \quad (4)$$

$$\rho_{Vac} = \rho_\Lambda = \frac{\Lambda c^2}{8\pi G} \quad (5)$$

H_0 is the Hubble constant.

a is the scale factor.

k is the intrinsic curvature.

Λ is the cosmological constant.

ρ_R is radiation energy density divided by the speed of light squared.

ρ_M is the matter (dark plus baryonic) energy density divided by the speed of light squared.

ρ_{Vac} is the vacuum energy density divided by the speed of light squared.

ρ_Λ is the cosmological constant energy density divided by the speed of light squared, it represent cosmological constant effect.

Figure 1. Formulae.

to evaluate the number of modes Mod which can meet this condition, which amounts to counting all the possible combinations of the integer n values. An approximation can be made by treating the number of combinations as line grid of the values, therefore will be function of one vacuum energy line.

Conclusion

The observed value of the cosmological constant poses large theoretical problems. We expose a point of view to the vacuum catastrophe, we use QED and model to build this theory. Cosmological constant problem could be caused by definition of , the error was replaced difference between all vacuum energy of the universe and could produce the vacuum catastrophe, we relate with one vacuum energy line to obtain the correct result.

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