The Vacuum Catastrophe

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Abstract

The Heisenberg uncertainty principle defines that $\Delta E * \Delta t \geq \frac{h}{4\pi}$. This leads us to the conclusion that even the vacuum has fluctuations of energy (zero point energy) which increases as the measurement time decreases. This energy is assumed to be generated by virtual particle pairs of matter and anti-matter that pop in and out of existence. This strange phenomena was demonstrated through the Casimir effect. This vacuum energy is supposed to be represented by Einstein's cosmological constant and assumed to be the source for the dark energy which was measured by the accelerating expansion of the universe. Since Δt can reach Planck time $\frac{l}{c}$, ΔE can reach $\frac{hc}{l}$ where h is Planck constant ,c is speed of light, l is Planck's length .When integrating all the expected energy due to vacuum fluctuations we receive an expected dark energy which is larger in 120 orders of magnitude from the observed expansion of the universe. This prediction failure of the theory versus observations leads to the vacuum catastrophe. This paper will suggest an approach that will enable to solve this major failure between predictions and observations.

Introduction

The black body radiation, ultraviolet catastrophe was solved by Planck's assumption that light can transfer energy only in quantized packets of $\frac{hc}{\lambda}$. This assumption predicts that most of the black body photonic energy will be resonated around the wave length that it's photonic energy ($\frac{hc}{\lambda}$) is equivalent to the thermal energy ($K_B T$) where

K_B Is the Boltzmann constant
h Is the Planck constant
c Is the speed of light
K Is the Boltzmann constant
T Is temperature in Kelvin
λ Is the wave length

Let's continue to the vacuum catastrophe with the same approach that solved the ultra violet catastrophe with the following assumptions:

Pairs of virtual matter and anti-matter particles that pop in and out of existence in the vacuum, based on the Heisenberg uncertainty principle, can become dark energy (energy that contribute to the expansion of the universe) **only** when a photon interacts with them and separates between them .When this happens, the virtual pair become real particles that wonder through space (figure 1) .

Hawking radiation happens when virtual particle pairs in the vacuum separate due to the black hole gravitation and become real particles on the horizon of the black hole and radiate into space, while the black hole shrinks, space expands. In a similar approach, these pair of virtual particles in the vacuum that were separated and become real matter and antimatter particles contribute dark energy and contribute to the expansion of space. When the vacuum generates real particles (energy) it expands.

The vacuum (empty space) is mostly governed by photons that are part of the cosmic microwave background radiation. Virtual particles pairs of matter and anti-matter that pop in and out of existence in the vacuum due to Heisenberg uncertainty principle can be approached as harmonic oscillators with the electromagnetic bond energy between them. Similar to the Planck equation of black body radiation, most of the virtual particles that will be separated and become real particles (the resonance frequency), generating dark energy into the vacuum, will have an electromagnetic bond energy which is correlated to the photonic energy of the cosmic microwave back ground radiation. The correlation parameter will be defined through the constant S.

$$\boxed{\Lambda_\nu(\nu,T) = F(h,c,\nu)\ \frac{1}{e^{\frac{h\nu}{SKT}}-1}} \qquad .1$$

Λ_ν Is the dark energy (Einstein's cosmological constant) as a function of the frequency (ν) in which virtual particles pop in and out of existence due to the Heisenberg uncertainty principle.

S Is the parameter defining the correlation between the thermal photonic energy of the vacuum (KT) due to the cosmic micro wave background radiation from the big bang and the expected resonance energy of the virtual particles popping in and out of existence that will be separated into real particles of matter and anti-matter due to interaction with these photons and will contribute to the dark energy. In the Planck's black body radiation equation S=1.

$F(h,c,\nu)$ Is a function of h, c, ν . In the Planck's black body radiation equation $F(h,c,\nu) = \frac{2h\nu^3}{c^2}$

h Is the Planck constant .

K Is the Boltzmann constant

c Is the speed of light in the vacuum .

T Is temperature in Kelvin of empty space due to the micro wave background radiation .

ν Is the frequency in which the virtual particle pairs, with the energy level $h\nu$, popping in and out of existence . $\nu = \frac{1}{\Delta t}$, while Δt is the measurement time sequence in the Heisenberg uncertainty principle.

Summary

The resemblance between the ultra violet catastrophe and the vacuum catastrophe lead me to look for similar mechanisms to solve the problem. The mechanism that solved the ultra violet catastrophe problem was to assume that the frequency band width of the oscillations in the molecules of the black body will be mainly concentrated where the photonic radiated energy $h\nu$ is around the value of its thermal energy KT and this derives the Planck black body radiation equation. By assuming the same mechanism and replacing the molecular oscillators with virtual particle pairs that pop in and out of existence in the vacuum in different frequencies, the higher the frequency of generation and annihilation the higher their mass and energy based on the Heisenberg uncertainty. The basic assumption is that the interaction with photons in the vacuum, generated during the big bang (micro wave back ground radiation), will separate some of these virtual pairs into real particles. The assumption is that similar to the black body radiation most of the separation will occur to the pairs with a bond energy correlated to the photonic energy of the micro wave back ground radiation. S Is the parameter defining the correlation between the thermal photonic energy of the vacuum (KT) due to the cosmic micro wave background from the big bang and the expected energy of the virtual particles popping in and out of existence that will be separated into real particles of matter and anti-matter due to interaction with these photons and will contribute to the dark energy. In the Planck's black body radiation equation S=1.

By tuning in equation 1 the right parameter of S and finding the right function $F(h, c, \nu)$, the integration over the frequencies $\nu = \frac{1}{\Delta t}$, where Δt defers from Planck's time , up to the age of the universe, we can receive the expected dark energy due to cosmological observations and overcome the vacuum catastrophe.

As space expands in a factor L, in each dimension, the photonic wave length of the cosmic micro wave back ground radiation expands in the same factor L and its thermal energy KT decreases. On the other hand the vacuum expands in the factor L^3 generating an increase number of virtual pairs popping in and out of existence. future calculations will show if this dark energy will increase, decrease or enter a stable mode.

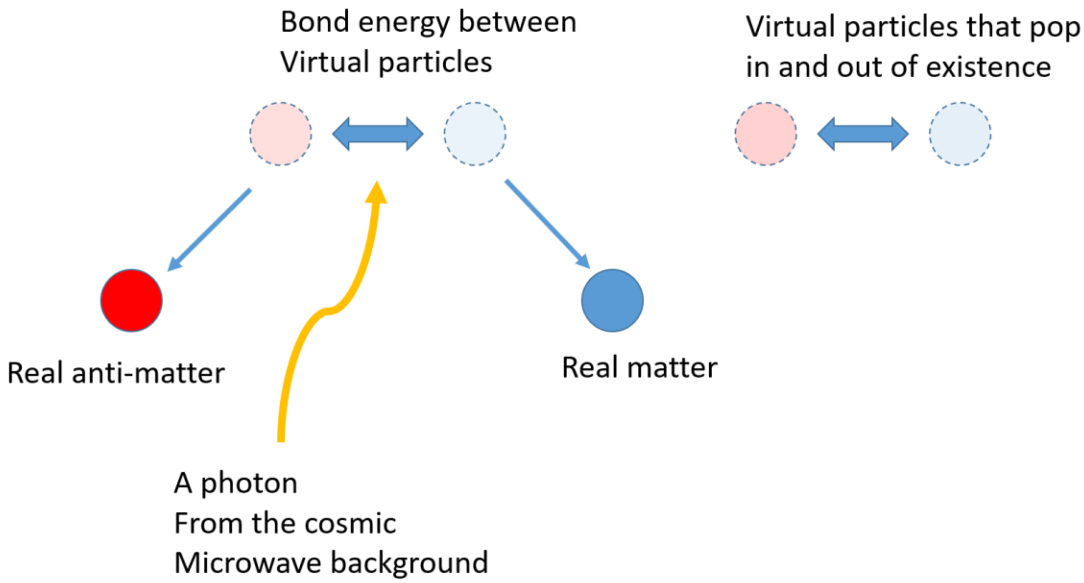

Figure 1: On the right is a pair of virtual particles that pop in and out of existence in the vacuum.

On the left is a pair of virtual particles that interact with a photon from the cosmic microwave background that has the right amount of energy to overcome their bond energy and transform them to real particles. When virtual particles generated by the vacuum become real particles the vacuum generates dark energy and expands.