The Detectability of Zero-point Vacuum Energy in Quantum Mechanics and General Relativity

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Abstract

The detectability of the zero-point vacuum energy in quantum mechanics and general relativity is discussed and its shown that the geometry also has a non-zero ground state which is independent from the ground state of energy density and that the principles of general relativity imply that the field equation should relate the deviation from these ground states rather than the absolute values of energy density and curvature.

Introduction

If we begin with Einstein's famous statement:" ***it is the theory which decides what can be observed*** **'' then the zero-point vacuum energy would be a meeting point for Quantum Mechanics and General Relativity only if we make sure that this quantity is observable in general relativity and if it is not observable we will show why we should not expect it to be related to the space-time curvature.**

The Existence and Detectability of the Ground State Energy

The zero-point energy of a system and its statistical result that the empty space has a non-zero ground state or lower energy density are direct and unavoidable results of quantum physics but the analysis of the detection of this ground energy density of vacuum by experiment shows that we can only measure the deviation from this energy density rather than its absolute value.

This " undetectability " of the zero-point vacuum energy density is not equivalent to non-existence in quantum physics because in quantum level we deal with systems which are not statistical where higher or lower levels of energy are probable and situations in which some of this energy is excluded from certain regions like the experiment known as Casmir Effect. But in the cosmological scale of general relativity the quantum zero-point vacuum energy is only a homogenous density that permeates all the space and there is no such differences to make it detectable.

To relate this undetectable quantity to a detectable geometrical quantity would be a violation to the most important of the fundamentals of general relativity which is summarized in Einstein's famous quote : '' ***Space-time and gravitation have no separate existence from matter*** **'' which he said when forced to summarize the general theory of relativity in one sentence. This statement is not a general or abstract philosophy but rather a very effective tool which led him to the field equation because it implies that t all the properties of matter must be found in the geometrical quantity which is related to it: this can be shown if we consider the reason for the selection of the quantity ($R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R$) to represent the geometrical side of the field equation from other unlimited number of other possible geometrical quantities (such as : $R_{\mu\nu} + gR_{\mu\nu}$, $g_{\mu\nu}R$, $RR_{\mu\nu}$, $g_{\mu\nu} R$ ... etc.) which is that the quantity ($R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R$) have the Bianci**

relation which tells us that : ($R_{\mu v} - \frac{1}{2} g_{\mu v} R$);v = 0 and thus a geometrical relation corresponding to the mass-energy conservation is gained. This means that our selection of the geometrical side of the field equation is based on the important assumption that all the properties of the material side must find a corresponding in the geometrical side, in other word, geometry and matter must be like two different languages that describe the same reality so we cannot for example select the quantity ($g\, g_{\mu v}\, R$) to be the geometrical side of the field equation and think that it is enough to think of a relation ($g g_{\mu v}\, R$);v = 0 as a result of the relation between matter and geometry without pure geometrical poof.

The Ground State Curvature of Space

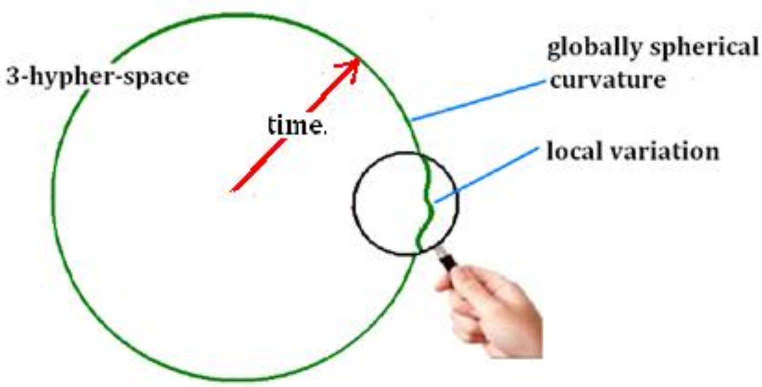
The assumption that in the absence of matter in the space-time the geometry is flat is not the best one because it is assumed to be based on the principle of simplicity while it can be seen that the flat space-time is more complex than a spherical 3-space with radial time (SSRT.) for many reasons such as:

1) Flatness involves arbitrary direction when embedded in another space.
2) SSRT. is symmetric while flat space is only symmetric if it is infinite.
3) In the SSRT. the passing of time and the expansion of the space may be seen as the same phenomenon.

In addition to other advantages of SSRT:

4) In SSRT the special nature of time is revealed.
5) In SSRT there is a meaning of the beginning of time.

Then if we adopt the spherical space with radial time we have in the absence of matter a non-zero value for the curvature of space which depends only in the age of the universe.



Then we can rewrite the field equation of general relativity as a relation between deviation of energy from the universal ground state (not only the quantum zero-point vacuum energy but all density of energy which is distributed homogenously in the universe) and the deviation from global curvature:

$$R_{\mu\nu} - \quad g_{\mu\nu}\, R \quad - \quad g_{\mu\nu}\, \Lambda \quad = \quad k\, T_{\mu\nu} \; - \quad k\, T_{\mu\nu}^{average}$$

Deviation from the geometrical ground state = Deviation from the material ground state

So all undetectable quantities is excluded from the field equation of general relativity because the zero-point energy density of vacuum or any other density which permeates all the space will not have any role in this equation because its contribution in ($k\, T_{\mu\nu}$) is canceled out by its contribution in ($k\, T_{\mu\nu}^{average}$).

Conclusion

1) Both the energy density and the curvature have a non-zero ground state .
2) We can only measure the deviation from the ground energy density so it is only detectable in quantum levels where lower or higher values for this energy are considerable.
3) The ground curvature of space depends only on the age of the universe and is detectable.
4) The field equation relates the deviation from the material ground state and the deviation from the geometrical ground state which can be done only by selecting a suitable form for the cosmological constant without changing any of the postulates of general relativity or quantum mechanics and this will solve the cosmological constant problem and many other major problems of modern cosmology without dark energy or (dark) period of inflation (see another paper by the same author : *A Comparison Between The Standard Cosmological Model and A Proposed Model with Radial Time and Independent Geometry*).