Compact dimensions and quantum vacuum

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Abstract

The vacuum energy depends on the inverse of the distance. That simple dependency may be hiding the geometry of the compact dimensions from string theory.

1. Introduction

The connection between the fractal dimension and the way in which fractal objects extend in space, and depend on distance, can be clearly seen in [1], where the dimension of simple figures such as the von Koch curve is calculated. In [2] it is indicated that the Heisenberg inequality relative to momentum and position destroys the classical concept of trajectory. The new quantum trajectories of the particles have a fractal structure: with increasing resolution the trajectory appears more and more chaotic.

The energy of the quantum vacuum fluctuations determines the very structure of the vacuum; therefore, it will be considered with a fractal structure and the cause of the fractal quantum trajectories. Its value on any scale depends on the inverse of the distance. It is identifiable with the conditions established in [3]. From the dependence of the energy of the vacuum with the distance its fractal dimension is calculated which is negative. But this value leads to consider the compact dimensions of string theory [4].

2. Exposition and discussion

The study of a fractal like Brownian motion is interesting for its simplicity. It was discovered by Robert Brown, a Scottish botanist who lived between the late 18th and first half of the 19th century. This movement has a fractal dimension 2, typical of a random variable that can cover a plane (topological dimension 2).

For isotropic variables with a topological dimension greater than unity, it is convenient to speak of the quotient D / δ (fractal dimension (D) / topological dimension (δ)). Thus, we reduce the dispersion of results and more easily find similes with simple examples such as one-dimensional trajectories. This quotient for the fractal representing the Brownian motion will be:

(1) $D/\delta = (\delta + \varepsilon) / \delta = (1 + 1) / 1 = 2$,

where the positive addend ε, which is added to the topological dimension, is a dimensional coefficient that indicates the irregularity of the fractal.

In this case $\varepsilon = 1$.

The fractal dimension gives us an idea of hidden magnitude, of compaction. A trajectory of fractal dimension 3 is much more compact than another of fractal dimension 2. In the first case the diameter of the occupied space would be of the order of the cube root of the total length of the trajectory, in the second of the order of its square root. There is an intimate relationship between the dependence of a fractal on distance and its dimension. Any phenomenon that modifies its dependence on distance will directly affect its fractal dimension and vice versa [4].

The energy of the vacuum fluctuations depends on the inverse of the distance, that indicates a quotient D / δ equal to -1, which supposes the existence of an unknown factor that is influencing the calculation and introducing a considerable distortion.

The negative factor, which involves a subtraction of dimensions, suggests the compact dimensions provided by superstring theory. This theory needs 9 spatial dimensions to be consistent, and, since we only know 3, it has been speculated that there are 6 others that would be compact around an extremely small radius (of the order of the Planck length). Thus, for distances much greater than that radius, only the ordinary 3 dimensions would be perceptible.

For those distances, the number of dimensions compacts subtracted from the total of the topological ones to leave only 3 dimensions. An operation contrary to the effect of the dimensional coefficient ε that is added to the topological dimension.

In expression (1) if we find the quotient D / δ for a Universe with the same number of compact dimensions as the value of the dimensional coefficient ε (transformation: $\delta \rightarrow \delta - \varepsilon$), we find:

(2) $D/\delta = (\delta) / (\delta - \varepsilon)$.

For ε = 6, δ = 3, the quotient D / δ takes the value -1 naturally. Without compact dimensions the factor ε = 6 assumes a fractal dimension 9 and a dependence of the energy of the fluctuations with the cube root of the distance (D / δ = 3). The effect of the compact dimensions corrects it until leaving it dependent on the inverse of the distance, in this way we observe the completely empty and stable quantum vacuum [4].

3. Conclusion

For a universe with a number of compact dimensions (negative dimensional coefficient) equal to the dimensional coefficient ε (positive coefficient) of the energy of fluctuations, the stabilization of this energy is achieved. Otherwise, it would depend on the cube root of the distance and not on its inverse. The vacuum and all matter would be warped and unstable.

The special geometry formed by ordinary and compact dimensions allows a stable quantum vacuum. As we approach distances on the order of Planck's length this effect disappears, and a warped and unstable vacuum is presented.

The vacuum transparency, as we know it, may be the best proof that there are 6 compact dimensions.

References

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