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[Vacuum energy](#)

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Field and particle theories

Quantum field theory considers the vacuum ground state not to be completely empty, but to consist of a seething mass of virtual particles and fields. Since these fields do not have a permanent existence, they are called vacuum fluctuations. In the Casimir effect, two metal plates can cause a change in the vacuum energy density between them which generates a measurable force.

Some believe that vacuum energy might be the "dark energy" (also called quintessence) associated with the cosmological constant in General relativity, thought to be similar to a negative force of gravity. Observations that the expanding Universe appears to be accelerating seem to support the Cosmic inflation theory —first proposed by Alan Guth (1981) — in which the nascent Universe passed through a phase of exponential expansion driven by a negative vacuum energy density (positive vacuum pressure).

Implications

Vacuum energy has a number of consequences. Vacuum fluctuations are always created as particle/antiparticle pairs. The creation of these "virtual particles" near the event horizon of a black hole has been hypothesized by physicist Stephen Hawking to be a mechanism for the eventual "evaporation" of black holes. The net energy of the universe remains zero so long as the particle pairs annihilate each other within Planck time. If one of the pair is pulled into the black hole before this, then the other particle becomes "real" and energy/mass is essentially radiated into space from the black hole. This loss is cumulative and could result in the black hole's disappearance over time. The time required is dependent on the mass of the black hole, but could be on the order of 10^{100} years for large solar-mass black holes.

The Grand unification theory predicts a non-zero cosmological constant from the energy of vacuum fluctuations. Examining normal physical processes with knowledge of these field phenomena can lead to an interesting insight in electrodynamics. During discussions of perpetual motion, the topic of vacuum energy usually encourages serious inquiries.

History

In 1934, Georges Lemaitre used an unusual perfect-fluid equation of state to interpret the cosmological constant as due to vacuum energy. In 1973, Edward Tryon proposed that the Universe may be a large scale quantum mechanical vacuum fluctuation where positive mass-energy is balanced by negative gravitational potential energy. During the 1980s, there were many attempts to relate the fields that generate the vacuum energy to specific fields that were predicted by the Grand unification theory, and to use observations of the Universe to confirm that theory. These efforts had failed so far, and the exact nature of the particles or fields that generate vacuum energy, with a density such as that required by the Inflation theory, remains a mystery.
