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Effective quantum gravity, cosmological constant and the Standard Model of particle physics

Abstract

The cosmological constant problem (CCP) and the formulation of consistent quantum gravity belong to the shortlist of the most important unsolved fundamental problems of physics. In the case of CCP the problem is to explain the extremely precise (55 orders in the Standard Model) fine-tuning between the independent vacuum part and the induced one, that is a function of symmetry breaking in the models of particle physics. The situation with CCP is so difficult that it makes sense to give up from attempting its solution and accept the need for a fine tuning between the vacuum and induced counterparts of the observed energy density of the vacuum. In this case, we meet the challenging situation with the renormalization group running of the vacuum or induced summands of the cosmological constant
at low energies.
Assuming the effective approach to quantum gravity and the Vilkovisky-DeWitt scheme of unique effective action, one can derive the exact, well-defined, renormalization group running of the vacuum cosmological constant. It turns out that, owing to the mentioned fine-tuning with the induced part, this running imposes severe restrictions on the possible extensions of the Minimal Standard Model of particle physics, concerning the magnitude of the vacuum expectation value of the corresponding Higgs fields.

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