Quantum fluctuations of axions and the cosmological constant problem

Luis Acedo

Department of Mathematics, Centro Universitario de Plasencia,
Calle Virgen del Puerto, 2,
University of Extremadura, 10600, Plasencia, Spain

Email: acedo@unex.es

The cosmological constant is now a fundamental ingredient of the standard ΛCDM model and its value is constrained by concordance with empirical data. Despite its importance in modern cosmology, we still do not understand its origin. A naive calculation of the contribution of the fluctuations of the quantum vacuum to vacuum energy (considering it to be the source of the cosmological constant) yields predictions 120 orders of magnitude larger than observations [1]. This poses one of the most celebrated unsolved problems in physics and cosmology, in particular.

In this work, we discuss a model of quantum thermal fluctuations of the cosmic microwave background with a Boltzmann factor. Fluctuations of a bosonic field are studied and we show that they could match the vacuum energy density if they correspond to an axionic field with a particle's rest mass in the range of a few meV. This mass range is in agreement with present bounds on the mass of the Peccei-Quinn's axions arising from the spontaneous symmetry breaking that explains CP conservation in weak interactions [2].

The relevance of this model to the Hubble tension debate [3], i. e., the statistically significant discrepancy among measurements of the Hubble parameter based upon the cosmic microwave background and those using the cosmic distance ladder, is also discussed. Our model also predicts a decreasing influence of the cosmological parameter or quintessence in the future of the Universe allowing for the possibility of recollapse. These scenarios are also studied and the options to distinguish them from ΛCDM are discussed.

(1) Weinberg, S. *Reviews of Modern Physics* **1989**, *61*, 1–23.

(2) Berenji, B.; Gaskins, J.; Meyer, M. *Phys. Rev. D* **2016**, *93* 045019, 045019.

(3) Efstathiou, G. *arXiv e-prints* **2020**, arXiv:2007.10716.