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Dirac fields in flat FLRW cosmology: uniqueness of the Fock quantization. (English)

Zbl 1364.81194
Ann. Phys. 376, 76-88 (2017).

Summary: We address the issue of the infinite ambiguity that affects the construction of a Fock quantization of a Dirac field propagating in a cosmological spacetime with flat compact sections. In particular, we discuss a physical criterion that restricts to a unique possibility (up to unitary equivalence) the infinite set of available vacua. We prove that this desired uniqueness is guaranteed, for any possible choice of spin structure on the spatial sections, if we impose two conditions. The first one is that the symmetries of the classical system must be implemented quantum mechanically, so that the vacuum is invariant under the symmetry transformations. The second and more important condition is that the constructed theory must have a quantum dynamics that is implementable as a (non-trivial) unitary operator in Fock space. Actually, this unitarity of the quantum dynamics leads us to identify as explicitly time dependent some very specific contributions of the Dirac field. In doing that, we essentially characterize the part of the dynamics governed by the Dirac equation that is unitarily implementable. The uniqueness of the Fock vacuum is attained then once a physically motivated convention for the concepts of particles and antiparticles is fixed.

MSC:

81T20 Quantum field theory on curved space or space-time backgrounds
81T70 Quantization in field theory; cohomological methods

Keywords:

quantum field theory in curved spacetimes; Fock quantization; uniqueness criteria; unitarity in cosmological backgrounds

Full Text: DOI

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