Arbitrary Gauge Unruh Effect

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Abstract

The Unruh effect is a quantum field theoretic phenomenon, originally proposed by Unruh, Fulling and Davies in 1976 (W. G. Unruh, Phys. Rev. D 14, 870 (1976)). The Unruh-Dewitt detector model is formally the same as the quantum Rabi model encountered in quantum optics, the conceptual tools of which have increasingly been utilised in analysing the Unruh effect (A. Belyanin, et al., Phys Rev Lett. 91, 243004 (2003)). The standard Unruh-Dewitt detector model and the associated notion of vacuum could be considered contrived in the sense that the counter-rotating interaction terms responsible for yielding a finite Unruh effect in the long-time limit, will, at finite times, yield similar detector vacuum excitations even when the detector is at rest. We focus on generalising the standard model and rewriting the Hamiltonian in an arbitrary gauge formalism. We find, even from a naïve approach of promoting the Hamiltonian to be time dependent, that different gauges yield different definitions of detector and vacuum, therefore resulting in different predictions on the existence of the Unruh effect. In fact, by fixing the Jaynes-Cummings gauge, one removes counter-rotating terms without making any rotating-wave approximation which provides a definition of vacuum and detector for which no virtual photons are present in the ground state. This means that detector excitation cannot occur whether or not the detector is accelerated. We aim to extend our analysis to include a more complete approach which would avoid making the Hamiltonian time-dependent and instead model the motion as externally prescribed at the Lagrangian level.

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