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Understanding gravitationally induced decoherence parameters in neutrino oscillations using a microscopic quantum mechanical model

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Open quantum systems provide a framework in which models for gravitationally induced decoherence can be formulated. In this talk a microscopic quantum mechanical model for gravitationally induced decoherence introduced by Blencowe and Xu is investigated in the context of neutrino oscillations. The focus lies on the comparison with existing phenomenological models and the physical interpretation of the decoherence parameters in such models. It will be shown that for neutrino oscillations in vacuum gravitationally induced decoherence can be matched with a subclass of phenomenological models. When matter effects are included, the decoherence parameters show a dependence on matter effects and thus vary in the different layers of the Earth. Such a dependence can be explained with the form of the coupling between neutrinos and the gravitational wave environment inspired by linearised gravity. As a consequence, in the case of neutrino oscillations in matter, the microscopic model does not agree with many existing phenomenological models that assume constant decoherence parameters in matter, and their existing bounds cannot be used to further constrain the model considered here. The probabilities for neutrino oscillations with constant and varying decoherence parameters are compared and it is shown that the deviations can be up to 10%. On a theoretical level, these different models can be characterised by a different choice of Lindblad operators, with the model with decoherence parameters that do not include matter effects being less suitable from the point of view of linearised gravity.

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