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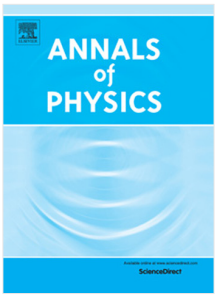

A path-integral approach to the problem of time

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A path-integral approach to the problem of time

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Abstract

Quantum transition amplitudes are formulated for model systems with local internal time, using intuition from path integrals. The amplitudes are shown to be more regular near a turning point of internal time than could be expected based on existing canonical treatments. In particular, a successful transition through a turning point is provided in the model systems, together with a new definition of such a transition in general terms. Some of the results rely on a fruitful relation between the problem of time and general Gribov problems.

Keywords: problem of time, quantum cosmology, Gribov problem
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1. Introduction

In relativistic systems, the lack of an absolute time parameter makes it impossible to implement the usual requirement of unitary quantum evolution in a straightforward manner. A local time variable is valid only for a finite range, so that coordinate changes are required in order to patch together classical trajectories. Corresponding transformations between quantum theories, describing the same system but based on different time choices, should then be used in order to patch together piecewise quantum evolutions. However, if evolution is unitary in each patch it can be extended indefinitely, beyond the classical range of the time parameter. The physical meaning of such an extension is unclear, in particular if it happens in semiclassical regimes such as small curvature of a cosmological model where one may expect small quan-

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