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• Tunneling into the Past: Quantum Creation of Time Machines

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One of the predictions of general relativity is the existence of spacetimes with nontrivial topology and causal structure. In principle, the real three-dimensional space could be multiply connected and could contain wormholes. As shown in the work of Novikov, a stable wormhole—if such an object exists—could, in principle, be turned into a time machine. When quantum field fluctuations are taken into account in a spacetime containing such a wormhole, these fluctuations grow significantly as the Cauchy horizon is approached. In particular, the renormalized stress energy tensor of the quantum field diverges at the Cauchy horizon, leading to an infinite energy density. This divergence is commonly interpreted as a sign that building a time machine is impossible—this is the essence of the chronology protection conjecture. However, that conclusion was reached by treating the wormhole throats' motion classically and by evaluating quantum effects in a fixed background geometry. In contrast, in the present paper we apply quantum mechanics to describe the motion of the wormhole throats. Within this approach, we obtain an estimate for the probability of creating a time machine, and this probability is found to be of order unity. The process closely resembles quantum tunnelling as known from ordinary quantum mechanics.

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