Quantum Physics

The role of chaos in quantum communication through a dynamical dephasing channel

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In this article we treat the subject of chaotic environments with few degrees of freedom in quantum communication by investigating a conservative dynamical map as a model of a dephasing quantum channel. When the channel's dynamics is chaotic, we investigate the model's semi-classical limit and show that the entropy exchange grows at a constant rate which depends on a single parameter (the interaction strength), analogous to stochastic models of dephasing channels. We analyze memory effects in the channel and present strong physical arguments to support that the present model is forgetful in the chaotic regime while memory effects in general cannot be ignored when channel dynamics is regular. In order to render the non-chaotic channel forgetful, it becomes necessary to apply a reset to the channel and this reset can efficiently be modeled by application of a chaotic map. We may then refer to encoding theorems (valid in the case of forgetful channels) to present evidence of a transition from noiseless to noisy channel due to the environment's transition from regular to chaotic dynamics.

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