A Novel Error Correction Scheme in Quantum Computing and Communication

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The presence of noise is ubiquitous in realistic physical systems. Entangled quantum bits represented by atoms, spins, photons, etc., often go through a process known as quantum decoherence due to environmental "noise". Decoherence is a major challenge for the practical realization of quantum computers and quantum information processing. To fix errors caused by noise in classical communication, bits are typically sent multiple times through the channel, and by probability the intended information can be obtained. In quantum regimes, error correction and quantum control are critical methods that protect quantum information from noise. In this paper, a new quantum error correction scheme is proposed based on an environment-assisted error correction to restore an unknown quantum state. By introducing a weak measurement reversal (WMR) operation, which can be realized through a variety of ways, such as the double Stern-Gerlach measurement or using Brewster-angle glass plates, we shall show how to recover an initial state of a quantum system without invoking random unitary decompositions which are known to be absent in many important physical systems. We illustrate our new scheme and compare it with schemes based on the pure weak measurement operation. In the proposed new scheme, the successful probability of recovering an unknown initial state can be significantly improved when the information obtained from an environment measurement is taken into account. Moreover, we show that the applicable range of our proposed scheme is wider than the WMR scheme. Finally, the optimization of the successful probability for possible Kraus decompositions is discussed. In our research, we performed numerical analysis extensively through the use of MATLAB and Mathematica.

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