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Discrete-Variable-Assisted Error Correction of Continuous-Variable Quantum Information

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Quantum information can be encoded as continuous wave functions in bosonic modes, but implementing error correction for such continuous-variable (CV) information remains a significant challenge. In this work, we propose a novel CV quantum error correction (QEC) scheme that leverages auxiliary discrete-variable (DV) systems as resources. By applying appropriate hybrid CV-DV coupling, we show that the fluctuation of mode quadratures induces a geometric phase on the DV system. Measuring the DV system thus enables the estimation and subsequent correction of the CV fluctuation noise. We demonstrate that even a single auxiliary qubit can suppress infidelity by 18%, and further improvement is possible by using higher-level ancilla. Furthermore, we propose that the DV ancilla can be encoded in noisy bosonic modes with established DV QEC. This introduces a new class of oscillator-in-oscillator code that is fundamentally different from the only known code, which relies on difficult-to-prepare GKP states.

Keyword-1

CV Quantum Information

Keyword-2

Quantum Error-Correction

Keyword-3

Hybrid Quantum Systems

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