Quantum control in ultrastrongly coupled matter and radiation

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Quantum operations with circuit QED hardware in the ultrastrong coupling (USC) are hindered by the dynamical Casimir effect (DCE), multiphoton generation deteriorating the fidelity even in absence of decoherence [1]. We show that a STIRAP-based [2] adiabatic protocol may overcome this limitation [3] since the cavity is never populated, operating as a virtual bus. Indeed we show that high fidelity fast operations can be performed for moderate couplings in the USC regime [3]. Moreover, properly crafted control extends the high fidelity region to even larger couplings//speed. The protocol is extremely robust against DCE, in the absence of decoherence yields almost 100% fidelity for remote population/state transfer. It is also resilient to decay due to leakage from the cavity, which is the main decoherence mechanism [3]. In this more realistic scenario, it is seen that for larger coupling (entering the deep strong coupling regime) the fidelity decreases due to the interplay between decoherence and DCE. Our results suggest that adiabatic manipulations may be a promising tool for quantum state processing in the USC regime.

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