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One hundred second bit-flip time in a two-photon dissipative oscillator

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Abstract

Current implementations of quantum bits (qubits) continue to undergo too many errors to be scaled into useful quantum machines. An emerging strategy is to encode quantum information in the two meta-stable pointer states of an oscillator exchanging pairs of photons with its environment, a mechanism shown to provide stability without inducing decoherence. Adding photons in these states increases their separation, and macroscopic bit-flip times are expected even for a handful of photons, a range suitable to implement a qubit. However, previous experimental realizations have saturated in the millisecond range. In this work, we aim to maximize the bit-flip time in a two-photon dissipative oscillator. To this end, we design a Josephson circuit in a regime that circumvents all suspected dynamical instabilities, and employ a minimally invasive fluorescence detection tool, at the cost of a two-photon exchange rate dominated by single-photon loss. We attain bit-flip times exceeding 100 seconds in between states containing about 40 photons. This experiment demonstrates that macroscopic bit-flip times are attainable with mesoscopic photon numbers in a two-photon dissipative oscillator. This lays a solid foundation from which the two-photon exchange rate can be gradually increased, thus gaining access to the preparation and measurement of quantum superposition states, and pursuing the route towards a logical qubit with built-in bit-flip protection.