Quantum feedback preparation and stabilization of photon number states of light in a cavity

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The stabilization of complex classical systems requires feedback. A sensor performs measurements of the system's state whose result is fed into a controller, which decides on an action bringing the system closer to a target state. Operating feedback for preparing and stabilizing against decoherence a quantum state is a promising tool for quantum control. It is however much more demanding than its classical counterpart, since a quantum measurement by the sensor changes the measured state. We present the first continuous operation of a closed feedback-loop for preparing and stabilizing photon number states of a microwave field stored in a high Q superconducting cavity. The field is probed by non-resonant Rydberg atoms performing Quantum Non-Demolition photon counting [1]. The feedback action consists either in the injection of a small coherent field pulse with a controlled amplitude and phase or in the emission and absorption of single photons with individual resonant atoms [2,3]. The atomic measurement results are fed into a real-time controller, which performs an estimation of the field's state before deciding on the actuator action bringing it closer to the target. We stabilize number states up to 7. We discuss further improvements of the non demolition photon counting method as well as other perspectives.

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