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Confining the state of light to a quantum manifold by engineered two-photon loss

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Physical systems usually exhibit quantum behavior, such as superpositions and entanglement, only when they are sufficiently decoupled from a lossy environment. Paradoxically, a specially engineered interaction with the environment can become a resource for the generation and protection of quantum states. This notion can be generalized to the confinement of a system into a manifold of quantum states, consisting of all coherent superpositions of multiple stable steady states. We have experimentally confined the state of a harmonic oscillator to the quantum manifold spanned by two coherent states of opposite phases. In particular, we have observed a Schrodinger cat state spontaneously squeeze out of vacuum, before decaying into a classical mixture. This was accomplished by designing a superconducting microwave resonator whose coupling to a cold bath is dominated by photon pair exchange. This experiment opens new avenues in the fields of nonlinear quantum optics and quantum information, where systems with multi-dimensional steady state manifolds can be used as error corrected logical qubits.