MAR13-2012-020097

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Cavity-assisted quantum bath engineering[1]

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In practice, quantum systems are never completely isolated, but instead interact with degrees of freedom in the surrounding environment, eventually leading to decoherence. Precision measurement techniques such as nuclear magnetic resonance and interferometry, as well as envisioned quantum schemes for computation, simulation, and data encryption, rely on the ability to prepare and preserve delicate quantum superpositions and entanglement. The conventional route to long-lived quantum coherence involves minimizing coupling to a dissipative bath. Paradoxically, it is possible to instead engineer specific couplings to a quantum environment that allow dissipation to actually preserve coherence. I will discuss our recent demonstration of quantum bath engineering for a superconducting qubit coupled to a microwave cavity. By tailoring the spectrum of microwave photon shot noise in the cavity, we create a dissipative environment that autonomously relaxes the qubit to an arbitrarily specified coherent superposition of the ground and excited states. In the presence of background thermal excitations, this mechanism increases the state purity and effectively cools the dressed atom state to a low temperature. We envision that future multi-qubit implementations could enable the preparation of entangled many-body states suitable for quantum simulation and computation.

[1]This work was supported by the IARPA CSQ program.