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Cavity Cooling for Ensemble Spin Systems

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Recently there has been a surge of interest in exploring thermodynamics in quantum systems where dissipative effects can be exploited to perform useful work. One such example is quantum state engineering where a quantum state of high purity may be prepared by dissipative coupling through a cold thermal bath. This has been used to great effect in many quantum systems where cavity cooling has been used to cool mechanical modes to their quantum ground state through coupling to the resolved sidebands of a high-Q resonator. In this talk we explore how these techniques may be applied to an ensemble spin system. This is an attractive process as it potentially allows for parallel remove of entropy from a large number of quantum systems, enabling an ensemble to achieve a polarization greater than thermal equilibrium, and potentially on a time scale much shorter than thermal relaxation processes. This is achieved by the coupled angular momentum subspaces of the ensemble behaving as larger effective spins, overcoming the weak individual coupling of individual spins to a microwave resonator. Cavity cooling is shown to cool each of these subspaces to their respective ground state, however an additional algorithmic step or dissipative process is required to couple between these subspaces and enable cooling to the full ground state of the joint system.