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Strong Coupling of a Donor Spin Ensemble to a Volume Microwave Resonator BRENDON ROSE, ALEXEI TYRYSHKIN, STEPHEN LYON, Princeton University — We achieve the strong coupling regime between an ensemble of phosphorus donor spins (5e13 total donors) in highly enriched 28-Si (50 ppm 29-Si) and a standard dielectric resonator. Spins were polarized beyond Boltzmann equilibrium to a combined electron and nuclear polarization of 120 percent using spin selective optical excitation of the no-phonon bound exciton transition. We observed a spin ensemble-resonator splitting of $580\,kHz$ (2g) in a cavity with a Q factor of 75,000 ($\kappa \ll \gamma \approx 120kHz$ where κ and γ are the external and internal resonator loss rates respectively). The spin ensemble has a long dephasing time ($9\,\mu s$) providing a wide window for viewing the time evolution of the coupled spin ensemble-cavity system described by the Tavis-Cummings model The free induction decay shows repeated collapses and revivals revealing a coherent and complete exchange of excitations between the superradiant state of the spin ensemble and the cavity (about 10 cycles are resolved). This exchange can be viewed as a swap of information between a long lived spin ensemble memory qubit ($T_2 \approx 2\,ms$) and a cavity

Brendon Rose
Princeton University

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