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Probing dynamics of a spin ensemble of P1 centers in diamond using a superconducting resonator[1] GIJS DE LANGE, VISHAL RANJAN, RON SCHUTJENS, Kavli Institute of Nanoscience, Delft University of Technology, THIBAULT DEBELHOIR, ICFP, Departement de Physique de l'ENS, JOOST GROEN, DANIEL SZOMBATI, DAVID THOEN, TEUN KLAPWIJK, RONALD HANSON, LEONARDO DICARLO, Kavli Institute of Nanoscience, Delft University of Technology — Solid-state spin ensembles are promising candidates for realizing a quantum memory for superconducting circuits. Understanding the dynamics of such ensembles is a necessary step towards achieving this goal. Here, we investigate the dynamics of an ensemble of nitrogen impurities (P1 centers) in diamond using magnetic-field controlled coupling to the first two modes of a superconducting (NbTiN) coplanar waveguide resonator. Three hyperfine-split spin sub-ensembles are clearly resolved in the 0.25-1.2 K temperature range, with a collective coupling strength extrapolating to 23 MHz at full polarization. The coupling to multiple modes allows us to distinguish the contributions of dipolar broadening and magnetic field inhomogeneity to the spin linewidth. We find the spin polarization recovery rate to be temperature independent below 1 K and conclude that spin out-diffusion across the resonator mode volume provides the mechanism for spin relaxation of the ensemble. Furthermore, by pumping spins in one sub-ensemble and probing the spins in the other sub-ensembles, we observe fast steady-state cross-relaxation (compared to spin repolarization) across the hyperfine transitions. These observations have important implications for using the three sub-ensembles as independent quantum memories.

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