Collective coupling of $\sim 10^{16}$ Fe$_8$ single-molecule magnets to a resonant cavity\textsuperscript{1} ANDREW EDDINS, JONATHAN FRIEDMAN, Department of Physics, Amherst College, CHRISTOPHER BEEDLE, DAVID HENDRICKSON, Department of Chemistry and Biochemistry, UCSD — When a spin resonantly couples to the electromagnetic mode of a cavity, spin and photon states hybridize producing entangled states and a “vacuum Rabi splitting” between the states. The magnetic-dipole transition between the coupled states results in a splitting $<100$ s$^{-1}$, practically unmeasurable. The well-known model of Tavis and Cummings \textsuperscript{[1]} predicts that for $N$ spins coupled to the cavity, the vacuum Rabi splitting is enhanced by $\sqrt{N}$. We performed a reflection spectroscopy experiment at 1.75 K on a single crystal of the Fe$_8$ single-molecule magnet (SMM) in a cylindrical cavity with a bare frequency of 147.6 GHz. An applied magnetic field brings the SMMs to resonance with this mode, resulting in an observed splitting of $\sim 3.4 \times 10^9$ s$^{-1}$. This value corresponds to $N \sim 2 \times 10^{16}$ Fe$_8$ SMMs collectively coupled to the cavity. From the dimensions of the crystal, we estimate a total of $N \sim 6 \times 10^{16}$ SMMs in the sample, suggesting that a substantial fraction of the crystal’s molecules are simultaneously coupled to the cavity. As temperature is increased, $N$ decreases, reducing the observed splitting. \textsuperscript{[1]} Phys. Rev., 170, 379 (1968).

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