The detection and characterization of paramagnetic species by electron-spin resonance (ESR) spectroscopy has numerous applications in chemistry, biology, and materials science [1]. Most ESR spectrometers rely on the inductive detection of the small microwave signals emitted by the spins during their Larmor precession into a microwave resonator in which they are embedded. Using the tools offered by circuit Quantum Electrodynamics (QED), namely high quality factor superconducting micro-resonators and Josephson parametric amplifiers that operate at the quantum limit when cooled at 20mK [2], we investigate magnetic resonance in a new regime where the quantum nature of the microwave field plays a role and the spin sensitivity is correspondingly enhanced. We report an increase of the sensitivity of inductively detected ESR by 5 orders of magnitude over the state-of-the-art, enabling the detection of 300 Bismuth donor spins in silicon with a signal-to-noise ratio of 1 in a single echo [3,4]. We also demonstrate that the energy relaxation time of the spins is limited by spontaneous emission of microwave photons into the measurement line via the resonator [5], which opens the way to on-demand spin initialization via the Purcell effect. Finally, we show that the sensitivity can be enhanced beyond the quantum limit by using quantum squeezed states of the microwave field [6].

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