Single spin magnetic resonance by microwave fluorescence detection

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We report a new method for electron spin detection at millikelvin temperatures. Analogous to the optical fluorescence detection of atoms or molecule, the method consists in detecting the microwave photons spontaneously emitted by the spins when they relax radiatively to their equilibrium ground state after being excited by a pulse (ie, their microwave fluorescence) [1]. To enhance the radiative relaxation rate [2], the spins are inductively coupled to a small-mode-volume, high-quality-factor, superconducting resonator patterned on top of the sample. The microwave fluorescence photons are then routed towards a single-microwave-photon detector [3] based on a superconducting qubit.

The method applies to all paramagnetic species with sufficiently low non-radiative decay rate. Here, we report the detection of rare-earth-ion spins (Er^{3+} in a scheelite $CaWO_4$ host matrix) by their microwave fluorescence. We perform a complete spectroscopic characterization of a small erbium ensemble. We also report the first microwave detection of individual erbium ion spins, and their coherent manipulation [4].

[1] E. Albertinale et al., Nature **600**, 434 (2021)
[2] A. Bienfait et al., Nature **531**, 74 (2016)
[3] R. Lescanne et al., Phys. Rev. X 10, 021038 (2020)
[4] Z. Wang et al., in preparation (2022)