Detecting spin fluorescence with a microwave photon counter

P. Bertet, Université Paris-Saclay, CEA Saclay

Quantum systems respond to illumination by a monochromatic field by emitting some signals that are phase-coherent with the driving tone, arising from the oscillating dipole induced on the emitters, and some signals that are incoherent (called fluorescence), arising from cycles of absorption/spontaneous emission undergone by each individual emitter. Atoms and molecules are routinely detected by their fluorescence, with important applications in quantum technology and fluorescence microscopy. Spins, on the other hand, are usually detected by the coherent component of their response, either in continuous-wave or pulsed magnetic resonance. Indeed, fluorescence detection requires emitters with a sufficiently large radiative decay rate, and also suitable detectors able to count individual photons, two major issues for spins that have a weak magnetic dipole transition and emit at rf or microwave frequencies where single photon detection is problematic. Using superconducting quantum devices, we have overcome these issues and detected a small ensemble of spins by their fluorescence at microwave frequency, at millikelvin temperatures [1]. We enhance the spin radiative decay rate by coupling them to a high-quality-factor and small-mode-volume superconducting resonator [2], and we connect the device output to a newly-developed microwave single photon counter based on a superconducting qubit [3]. I will discuss the potential of fluorescence detection as a novel methodology for magnetic resonance spectroscopy of small numbers of spins, and show its application to Rare-Earth-Ions doped crystals [4].

[1] E. Albertinale et al., to appear in Nature (2021), arxiv:2106.01415

[2] A. Bienfait et al., Nature 531, 74 (2016)

[3] R. Lescanne et al., Phys. Rev. X 10, 021038 (2020)

[4] E. Billaud et al., in preparation (2022)