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29th RQC Colloquium

Single Atom Magnetic Resonance by Microwave Photon Counting

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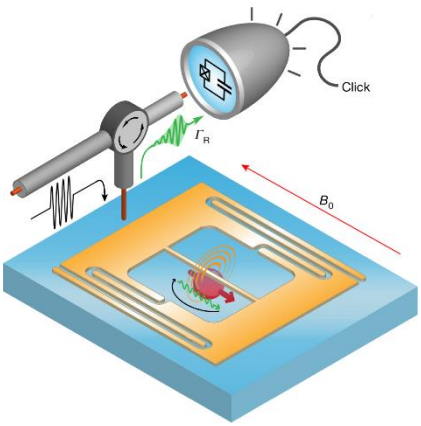
December 10, 2024(Tue) **16:00–17:00**(JST)

This colloquium will be held in **HYBRID** format.

On-site Venue: Wako C00 HQ 2F Large Meeting Room

Online Venue: Zoom. To receive the link, register in advance at https://krs2.riken.jp/m/rqc_registration_form

Electron spin resonance (ESR) spectroscopy is a widely used technique for characterizing paramagnetic impurities, with applications ranging from chemistry to quantum computing. However, it is typically limited to ensemble-averaged measurements due to its restricted signal-to-noise ratio. Sensitivity sufficient to detect single electron spins has been achieved through methods such as spin-dependent photoluminescence, transport measurements, and scanning probes. Unfortunately, these techniques are often system-specific or sensitive to a small detection volume, leaving practical single-spin detection an ongoing challenge. Here, we demonstrate single-electron magnetic resonance via spin fluorescence detection [1], utilizing a microwave photon counter based on a superconducting transmon qubit operating at millikelvin temperatures. In our experiment, individual paramagnetic erbium ions in a scheelite $CaWO_4$ crystal are manipulated and read out, enabled by magnetic coupling with a small-mode-volume, high-quality-factor superconducting microwave resonator. Leveraging this capability, we perform nuclear magnetic resonance of the nearby ^{183}W nucleus [2], achieving single-shot nuclear spin readout and demonstrating second-scale coherence times for individual atoms. This quantum control over individual high-coherence nuclei opens new avenues for quantum computing. Our method, applicable to arbitrary paramagnetic species with sufficiently long non-radiative relaxation times, enables large detection volumes (~10 μm^3), paving the way for ESR at the single-molecule level with unprecedented sensitivity and spectral resolution.



[1] Z. Wang *et al.*, Nature **619**, 276–281 (2023).

[2] J. Travesedo *et al.*, arXiv:2408.14282

If you have any questions about the colloquium, please contact: rqc_colloquium_inquiry[at]ml.riken.jp

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