MILLISECOND-SCALE SPIN COHERENCE OF ^{171}Yb QUBITS IN $CaWO_4$ AT A ZERO-FIELD CLOCK TRANSITION

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Solid-state spin systems are attractive qubit candidates due to their scalable integration with existing microwave technologies and their long spin coherence times [1], defined as the duration over which a quantum superposition is preserved. In this context, rare-earth ions are particularly promising because their shielded 4f electrons lead to narrow transition linewidths and reduced coupling to the host lattice, enabling enhanced coherence in magnetically weak crystalline environments, which is necessary for quantum networks [2]. Further suppression of decoherence can be achieved by operating at clock transitions, where the spin transition frequency is first-order insensitive to magnetic field fluctuations, as demonstrated in both silicon-based [3] and rare-earth spin systems [4].

Ytterbium doped into $CaWO_4$ is a particularly attractive platform owing to the low magnetic noise environment of the host crystal with previous demonstrations of sub-second coherence using optical transitions [5]. In this study, we investigate the spin coherence enhancement at the 3.1 GHz clock transition for $^{171}Yb^{3+}$:$CaWO_4$ by direct measurements using pulsed electron spin resonance (ESR) spectroscopy. Spin coherence is probed using two ESR spectrometers: a Bruker ELEXSYS E580 operating at X-band frequencies (9-10 GHz) and a home-built low-frequency spectrometer covering the 1-6 GHz range. Low sensitivity parallel-mode ESR measurements are enabled by custom tunable loop-gap resonators equipped with a developed S-band cryoprobe. Temperature-dependent measurements reveal that below 4 K the coherence time is not limited by spin-lattice relaxation. At the clock transition, spin coherence times exceed 1 ms with decoherence dominated by direct spin flip-flop processes (Fig. 1).

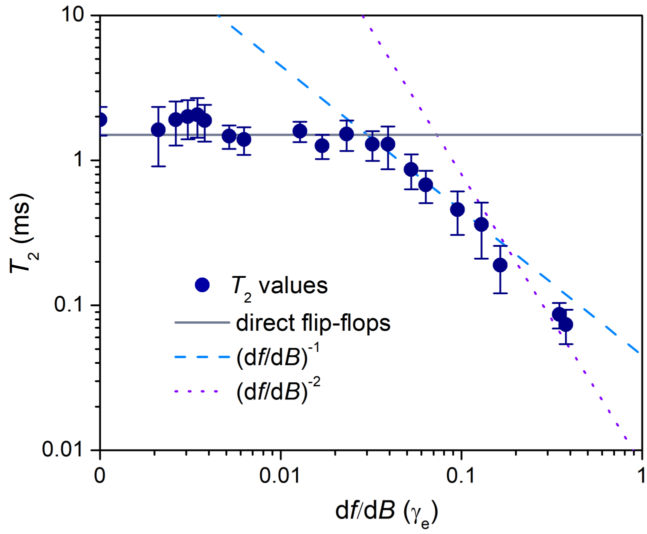

Fig. 1. Coherence time enhancement when approaching the zero-field clock transition.

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Keywords: Spin qubit, rare-earth ion, clock transition, coherence time, electron spin resonance

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