Narrow optical and spin linewidths in 171Yb:CaWO4

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Abstract

Optically addressable solid-state spins have been extensively studied for quantum technologies,
offering unique advantages for quantum computing, communication, and sensing. Advancing

these applications is generally limited by finding materials that simultaneously provide lifetime-

limited optical and long spin coherences. Here, we introduce 171Yb3+ ions doped into a CaWO4

crystal. We perform high-resolution spectroscopy of the excited state, and demonstrate all-optical

coherent control of the electron-nuclear spin ensemble. We find narrow inhomogeneous broadening

of the optical transitions of 185 MHz and radiative-lifetime-limited coherence time up to 0.75 ms.

Next to this, we measure a spin-transition ensemble line width of 5 kHz and electron-nuclear spin

coherence time reaching 0.15 seconds at zero magnetic field between 50 mK and 1 K temperatures.

These results demonstrate the potential of 171Yb3+:CaWO4 as a low-noise platform for building

quantum technologies with ensemble-based memories, microwave-to-optical transducers,
and optically addressable single-ion spin qubits.

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