Probing direct spin-phonon interactions with bulk acoustic wave resonators

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Abstract:

Understanding spin-phonon interactions is essential for solid-state quantum technologies that exploit the spin degree of freedom. Experimental probes for spin-phonon interaction in the quantum regime are therefore needed. We developed a versatile technique to probe the resonant coupling of solid-state spin defects to strain in very wide range of target crystals. Our technique consists in measuring high overtone bulk acoustic wave resonators (HBAR) made out of crystals hosting spin defects, at 50 mK, within a vector magnetic field. By bonding a thin-film lithium niobate transducer onto the target crystal, we couple to its HBAR modes at GHz frequencies. Our procedure does not require fabrication on the target crystal. It is relatively simple and robust, and yields functional HBAR with finesses up to 50 on double-side polished crystals. On CaWO4 crystals doped with Er3+ ions, we demonstrate acoustic paramagnetic resonance and we unveil the angular dependence of spin-phonon interactions.

Figures

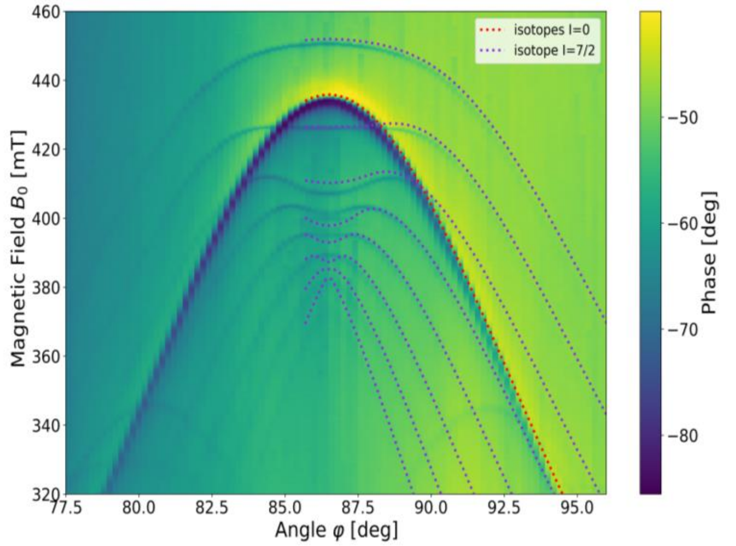

Figure 1: This graph shows the interactions between an acoustic mode at w_m =7.606GHz with Er3+ ions at frequency w_s in the (bc) plane of CaWO4. This measurement highlights the phase shift when $w_m = w_s$. The purple lines represent the interactions expected for Er3+ with I=7/2, while the red line corresponds to the Er3+ with I=0.