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Strain-mediated mechanical coupling to diamond spins[1]

ANIA BLESZYNSKI JAYICH, UC Santa Barbara

Nitrogen-vacancy (NV) centers in diamond are atomic-scale spin systems with remarkable quantum properties that persist to room temperature. The recent demonstration of high-quality single-crystal diamond resonators has led to significant interest in a hybrid system consisting of NV spins that interact with the resonant phonon modes of a macroscopic mechanical resonator through crystal strain. We demonstrate dynamic, strain-mediated coupling of the mechanical motion of a diamond cantilever to the spin of an embedded NV. Via quantum control of the spin, we quantitatively characterize the axial and transverse strain sensitivities of the nitrogen–vacancy ground-state spin. The nitrogen–vacancy center is an atomic scale sensor and we demonstrate spin-based strain imaging with a strain sensitivity of $3\text{x}10^{-6}$ strain $\text{Hz}^{1/2}$. We discuss prospects for reaching the regime of quantum coupling between phonons and spins, and we present our results in this direction. This hybrid system has exciting prospects for a phonon-based approach to integrating NVs into quantum networks.

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