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**Mechanical driving of nitrogen-vacancy center spins in diamond**

E.R. MACQUARRIE, T.A. GOSAVI, N.R. JUNGWIRTH, S.A. BHAVE, G.D. FUCHS, Cornell University — We demonstrate direct coupling between nitrogen-vacancy (NV) center spins and cavity phonons by driving spin transitions with mechanically-generated harmonic strain, without mediation by a magnetic field. Using a bulk-mode acoustic resonator fabricated from single-crystal diamond, we exert $\sim 7$ MPa of non-axial ac stress on the NV centers within the substrate. When we tune the $m_s = +1 \leftrightarrow m_s = -1$ spin state splitting into resonance with a $\sim 1$ GHz mechanical mode, we observe a $\Delta m_s = \pm 2$ spin transition, which is forbidden by the magnetic dipole selection rule. Additionally, we find that the amplitude of the spin signal varies with the spatial periodicity of the stress standing wave, verifying that NV center spins are directly driven by mechanical oscillations. These direct spin-phonon interactions provide a new opportunity for quantum control and enable studies of spin-phonon interactions at the nanoscale.

Evan MacQuarrie
Cornell University

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