

Abstract Submitted  
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**Towards a Quantum Interface between Diamond Spin Qubits and Phonons in an Optical Trap** PENG JI, M. UMMAL MOMEEN, JEN-FENG HSU, BRIAN D'URSO, GURUDEV DUTT, Department of Physics and Astronomy, University of Pittsburgh — We introduce a method to optically levitate a pre-selected nanodiamond crystal in air or vacuum. The nanodiamond containing nitrogen-vacancy (NV) centers is suspended on a monolayer of graphene transferred onto a patterned substrate. Laser light is focused onto the sample, using a home-built confocal microscope with a high numerical aperture ( $NA = 0.9$ ) objective, simultaneously burning the graphene and creating a 3D optical trap that captures the falling nano-diamond at the beam waist. The trapped diamond is an ultra-high-Q mechanical oscillator, allowing us to engineer strong linear and quadratic coupling between the spin of the NV center and the phonon mode. The system could result in an ideal quantum interface between a spin qubit and vibrational phonon mode, potentially enabling applications in quantum information processing and sensing the development of quantum information storage and processing.

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