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Quantum Non-Demolition Measurements between a Graphene Nanomechanical Resonator and a Diamond Nitrogen-Vacancy Center[1]

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A description of the motion of microscopic particles often requires quantum mechanics, but macroscopic objects are typically observed to follow the predictions of classical mechanics. In the transition from microscopic components to a complex macroscopic system, the distinctive features of quantum mechanics can be hidden by thermal excitations and coupling to the environment. In particular, while individual spins are intrinsically quantum objects, nanomechanical resonators are usually observed as classical damped oscillators. With a careful choice of coupling, these two systems can be made to interact such that they perform quantum non-demolition (QND) measurements on each other, enabling a bridge between the quantum and classical worlds. Through this coupling, the nanomechanical resonator provides a classical readout of the spin, while the spin acts as a probe of the discrete quantum states of the resonator. We present a system consisting of a graphene nanoelectromechanical resonator coupled to a single spin through a uniform external magnetic field. The spin originates from a nitrogen-vacancy (NV) center in a diamond nanocrystal, which is positioned on the resonator. The external magnetic field provides quadratic coupling which results in QND measurements between the spin and resonator. The strength of the quadratic coupling is enhanced by utilizing an avoided level crossing of the coupled spin-resonator system. The low mass of a graphene resonator further increases the sensitivity to the force associated with a single spin. NV centers are chosen as the source of a spin due to their exceptional spin state coherence times, large zero-field splitting, and optical addressability. We will present an analysis of the system and report on the status of experimental measurements with graphene-NV center devices.

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