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Nonlinear Optomechanics for Quantum Nondemolition Measurements

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Since its inception in the early 1900s, the theory of quantum mechanics has provided an excellent model for very small objects, such as single atoms or molecules. However, as we move to larger and larger systems, we eventually return to the classic realm, where Newtonian mechanics takes over. In order to probe this quantum-to-classical crossover, we propose an experiment by which we can measure the quantum nature of a nanomechanical resonator, consisting of billions to trillions of atoms. Using a coupling apparatus on the base plate of a dilution refrigerator, we will cool an optomechanical device such that it is predominantly in its ground state. Then by utilizing a nonlinear coupling mechanism, we will perform an optical quantum nondemolition measurement to probe our mechanical resonator, preventing destructive measurement back-action from perturbing the system. In the context of optomechanics, this arises as an "x-squared"measurement, which we have demonstrated for a nanofabricated on-chip device. Under the proper conditions, we expect to be able to directly observe quantized jumps in the phonon number of our system, providing "smoking gun" evidence for quantum mechanics on the mesoscale. In my talk, I will discuss how we will perform such an experiment using our nonlinearly coupled optomechanical system.

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