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Theory of force detection using optically levitated nanoparticles[1]

BRANDON RODENBURG, Rochester Inst of Tech, LEVI NEUKIRCH, ROBERT PETTIT, NICK VAMIVAKAS, University of Rochester, MISHKAT BHATTACHARYA, Rochester Inst of Tech — Levitated nanoparticles offer the potential of being incredibly well isolated from the environment. This isolation makes such systems excellent candidates for tests of quantum mechanics at the macroscale and as versatile platforms for ultrasensitive metrology. Systems involving an optical cavity mode to provide the trapping field, as well as cooling mechanism of the particle's center of mass motion are well understood theoretically and provide a canonical system for the field of quantum optomechanics. However, techniques based on measurement based parametric cooling and feedback stabilization have made it possible to trap and manipulate a nanoparticle without the need for an optical cavity, even at extremely high vacuum where gas damping cannot stabilize the motion of the particle. For these cavityless systems, a fully quantum theory has recently been developed. In this talk we will present recent work that we have carried out to apply this theory to the use of such devices as force sensors, including a discussion of the ultimate limits placed on the sensitivity by the sources of fundamental quantum noise.

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