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Ultra-sensitive force measurement using optically levitated microspheres ALEXANDER RIDER, DAVID MOORE, GIORGIO GRATTA, Stanford Univ — We have demonstrated a novel technique for measuring microscopic forces acting on optically levitated dielectric microspheres. The radiation field at the focus of a laser beam is used to levitate a microsphere in a harmonic trap where its displacement can be determined by the pattern of scattered light. Optical levitation isolates the microsphere from the surrounding environment at high vacuum, making thermal noise negligible. We have demonstrated a preliminary sensitivity of $5 \times 10^{-17} NHz^{-1/2}$ for forces acting on $5\mu m$ microspheres and expect to be able to improve this by several orders of magnitude once non-fundamental sources of noise are eliminated. The electric charge of a microsphere can be determined by applying an electric field and measuring the resulting force. We have demonstrated the ability to discharge the microspheres with single electron precision, which eliminates the most significant electrostatic backgrounds from force measurements. As a demonstration of this technique we have searched for the presence of unknown charged particles with charge $> 5 \times 10^{-5} e$ bound in our microspheres. Here we discuss the apparatus, the charged particle search, and outline our plans for future measurements including gravity at μm length scales.

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