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Limits on non-Newtonian gravity at 10 μm scale by precision force measurements with optically-levitated microspheres

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The universal law of gravity has undergone stringent tests for a long time over a significant range of length scale, from an atomic scale to a planetary scale [1]. Of particular interest is the short distance regime, where modifications to Newtonian gravity may arise from axion-like particles [2] and extra dimensions [1]. We have constructed a precision force sensor based on optically-levitated microspheres with a force sensitivity of $\sim 10^{-17}$ N/$\sqrt{\text{Hz}}$ [3] for the purpose of increasing the sensitivity of searches for non-Newtonian forces in the 1-100 μm range. In our scheme, the microsphere interacts with a variable-density attractor mass made by alternating silicon and gold segments with periodicity on the order of 10 μm, which is the same as the distance between the microsphere and the attractor. We report on the performance of this technique, its sensitivity, and some initial results. Further technological developments to reduce background are expected to provide orders of magnitude improvement in the sensitivity, going beyond current constraints [4-8].

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