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A Cantilever-based apparatus for detecting micron-scale deviations from Newtonian gravity[1]

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To test new theories of physics beyond the Standard Model, we have built a low temperature probe to measure forces as small as 10^{-18} N between masses separated by distances on the order of 20 microns. Our experiment is fundamentally a Cavendish-type experiment in the sense that its purpose is to directly measure the force between two masses [1]. A cryogenic helium gas bearing is used to rotate a disc containing a drive mass pattern of alternating density under a small test mass mounted on a micromachined cantilever. Any mass-dependent force between the two will produce a time-varying force on the test mass, and consequently a time-varying displacement of the cantilever. This displacement is read out with a laser interferometer, and the position of the drive mass is simultaneously recorded using an optical encoder. The displacement is then averaged over many cycles and converted to a force using measured properties of the cantilever. This AC "lock-in" type measurement enables significant noise rejection and allows us to operate on resonance to take advantage of the cantilever's high quality factor. A novel feature of the apparatus is the utilization of feedback regulation of the response of the microcantilever using the radiation pressure of a laser. Our approach does not require a high-finesse cavity, and the feedback force is due solely to the momentum of the photons in the second laser.

[1] D.M. Weld, J. Xia, B. Cabrera, and A. Kapitulnik, Phys. Rev. D 77, 062006 (2008).

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