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The Muonium Antimatter Gravity Experiment

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A direct measurement of the gravitational acceleration of antimatter has the potential to show that we live in a "Dirac-Milne" Universe, which could explain cosmological observations without the need for dark matter, dark energy, inflation, or missing antimatter. Such a measurement would also be sensitive to the possible existence of a fifth force. Cooling antimatter to temperatures where gravitational energies are comparable to thermal energies is challenging for most forms of antimatter, which annihilate upon contact with matter. The exception is the antimuon (μ+), which is easily cooled by stopping in cold matter, but the short muon lifetime poses challenges. Positive muons that stop in material will combine with free electrons to form muonium, a neutral leptonic atom with most of its mass derived from the 2nd-generation antimuon. We are developing the Muonium Antimatter Gravity Experiment (MAGE) to measure the gravitational force on muonium using a novel, monoenergetic, low-velocity, horizontal muonium beam directed at an ultra-precise atom interferometer. If successful, MAGE will measure for the first time the gravitational coupling to a 2nd-generation particle in a system whose antimatter-dominated mass is not predominantly strong-interaction binding energy. The novel MAGE beam production approach could also have important applications to other muonium experiments as well as to the measurement of g-2.

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