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New Directions for Fundamental Physics Tests with Macroscopic Scale Atom Interferometers

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Light-pulse atom interferometry—which uses optical pulses to split, recombine, and interfere quantum mechanical atomic matter waves—is a sensitive method for measuring inertial and gravitational forces, making it a valuable tool for a broad set of applications and fundamental physics tests. The sensitivity of an atom interferometer scales with its enclosed spacetime area, which is proportional to the product of the maximum spatial separation reached between the two interferometer paths and the interferometer duration. Motivated by this scaling, atom interferometers have been realized that cover macroscopic scales in space (tens of centimeters) and in time (multiple seconds). In this talk, I will discuss new experimental efforts to use macroscopic scale atom interferometers for fundamental physics tests. These include improved searches for new particles beyond the standard model by looking for deviations from the gravitational inverse square law and an improved measurement of Newton's gravitational constant. Additionally, I will discuss work that the Matter wave Atomic Gradiometer Interferometric Sensor (MAGIS) collaboration is pursuing toward a large scale atom interferometer to search for ultralight dark matter and to detect gravitational waves in a frequency band complementary to those addressed by laser interferometers.

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