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) [1-3].

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 [4], an improved measurement of Newton’s gravitational constant, and the study of quantum systems in curved spacetime [2] in a new regime in which beyond-semiclassical effects dominate. Additionally, I will provide an update on efforts to pursue a large scale atomic gravitational wave and dark matter detector.

Figure: Interference patterns from a macroscopic scale atom interferometric gravity gradiometer (actual data) [2].


