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Gravitational Physics with Atom Interferometry

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The notion of wave-particle duality is fundamental in the quantum mechanical description of matter. This duality asserts that matter sometimes behaves like a particle and sometimes behaves like a wave, called de Broglie waves. Recent advances in methods to coherently manipulate de Broglie waves of atoms have enabled a new generation of atom interferometers with unique capability to address outstanding fundamental science challenges. The method has emerged as a tool capable of addressing a diverse set of questions in gravitational physics and quantum physics, and as a technology for advanced sensors for navigation and for measurement of the Earth's gravitational field. We will discuss an experiment consisting of a tungsten mass and atomic wave packets separated by about 25cm. In this experiment, the relative phase of the interfering wave packets is shown to depend on the gravitational interaction in a way which is analogous to the so-called Aharonov-Bohm effect for charged particles. We will describe the relevance of these results to observation of quantum superpositions of Newtonian gravitational fields. Future science and technology applications will also be described, including the detection of dark matter, detection of gravitational waves at frequencies below 1 Hz and satellite geodesy.

Keyword-1

gravitational

Keyword-2

quantum

Keyword-3

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