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Precision Inertial Sensing Using Atom Interferometry

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Recent advances in atom optics and atom interferometry have enabled observation of atomic de Broglie wave interference when atomic wavepackets are separated by distances approaching 10 cm and times of nearly 3 seconds. With further refinements, these methods may lead to meter- scale superpositions. In addition to providing new tests of quantum mechanics, these methods allow inertial force sensors of unprecedented sensitivity. We will describe methods demonstrated and results obtained in a 10 m atomic fountain configuration [1-2], their implications for technological applications in geodesy and inertial navigation, and their relevance to fundamental studies in gravitational physics [3]. We will describe supporting techniques used to cool atoms to effective temperatures of $\sim$ 15 pK in two dimensions and novel atom optics configurations which have achieved greater than 5 sec of quasi-inertial free fall. Finally, we will discuss the prospects of incorporating spin-squeezing methods to improve interferometer signal-to-noise.

[1] Dickerson, Susannah M., Jason M. Hogan, Alex Sugarbaker, David M. S. Johnson, and Mark A. Kasevich. "Multiaxis Inertial Sensing with Long-Time Point Source Atom Interferometry." Physical Review Letters 111, no. 8 (August 19, 2013): 083001.

[2] Sugarbaker, Alex, Susannah M. Dickerson, Jason M. Hogan, David M. S. Johnson, and Mark A. Kasevich. "Enhanced Atom Interferometer Readout through the Application of Phase Shear." Physical Review Letters 111, no. 11 (September 10, 2013): 113002.

[3] Graham, Peter W., Jason M. Hogan, Mark A. Kasevich, and Surjeet Rajendran. "New Method for Gravitational Wave Detection with Atomic Sensors." Physical Review Letters 110, no. 17 (April 25, 2013): 171102.