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Atom Interferometry using Bose-Einstein condensates on Earth and in Space[1]

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Atom interferometry is a precision measurement technique in which a quantum mechanical wave function for a particle is split into two or more parts that are separated in space. At a later time, the parts are recombined, with a result that depends on the quantum phase evolution along the different trajectories taken. This phase is sensitive to environmental effects, and it is particularly well suited to measure inertial effects like gravity or rotation. These measurements are potentially useful for inertial navigation, mineral exploration, and other applications. Terrestrial experiments have used atom interferometry to demonstrate sensing with record-breaking precision and accuracy, but the usable measurement time is limited by the particles falling in gravity. This problem is avoided in the microgravity environment of near-earth orbit, making it an ideal platform to pursue even higher precision. The application to inertial navigation is also important in space, where external navigation markers are often unavailable. The recent approval of the Cold Atom Lab aboard the International Space Station will allow preliminary tests of atom interferometry in space, using a Bose-Einstein condensate of atoms at nearly zero temperature. We will discuss the challenges and opportunities this presents. We will also describe ground-based efforts to simulate the effect of microgravity so as to improve interferometer performance.

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