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Gravitational wave detection using atom interferometry

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The advent of gravitational wave astronomy promises to provide a new window into the universe. Low frequency gravitational waves below 10 Hz are expected to offer rich science opportunities both in astrophysics and cosmology, complementary to signals in LIGO's band. Detector designs based on atom interferometry have a number of advantages over traditional approaches in this band, including the possibility of substantially reduced antenna baseline length in space and high isolation from seismic noise for a terrestrial detector. In particular, atom interferometry based on the clock transition in group II atoms offers tantalizing new possibilities. Such a design is expected to be highly immune to laser frequency noise because the signal arises strictly from the light propagation time between two ensembles of atoms. This would allow for a gravitational wave detector with a single linear baseline, potentially offering advantages in cost and design flexibility. In support of these proposals, recent progress in long baseline atom interferometry in a 10-meter drop tower has enabled observation of matter wave interference with atomic wavepacket separations exceeding 50 cm and interferometer durations of more than 2 seconds. This approach can provide ground-based proof-of-concept demonstrations of many of the technical requirements of both terrestrial and satellite gravitational wave detectors.