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Fundamental Limitations of Cavity-assisted Atom Interferometry

Atom interferometers employing optical cavities to enhance the beam splitter pulses promise significant advances in science and technology, notably for future gravitational wave detectors. Long cavities, on the scale of hundreds of meters, have been proposed in experiments aiming to observe gravitational waves with frequencies below 1 Hz, where laser interferometers, such as LIGO, have poor sensitivity. Alternatively, short cavities have also been proposed for enhancing the sensitivity of more portable atom interferometers. We explore the fundamental geometrical and optical limitations of two-mirror cavities for large momentum beam splitting and establish upper bounds on the temperature of the atomic ensemble as a function of cavity length. An upper limit to cavity length based on optical constraints is found for symmetric two-mirror cavities, restricting the practicality of long baseline detectors. For shorter cavities, an upper limit on the beam size was derived from the geometrical stability of the cavity. These findings aim to aid the design of current and future cavity-assisted atom interferometers.

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