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Precision Atom Interferometry with Bose-Einstein Condensates

ALAN JAMISON, VLADYSLAV IVANOV, NATHAN KUTZ, SUBHADEEP GUPTA, University of Washington — Interferometry using laser cooled atom sources diffracted by standing waves of light can achieve remarkable sensitivity in diverse measurements such as that of local gravity, gravity gradients, and atomic photon recoil. A key feature of these achievements is the small velocity distribution of laser cooled atom sources. While a Bose-Einstein condensate (BEC) source provides an even narrower velocity distribution, the higher atomic interaction energy (mean field) introduces a new systematic error to the measurement. Using a contrast atom interferometry technique with sodium Bose-Einstein condensates (BEC), atomic photon recoil has been measured [1] to 7 parts per million (ppm) precision but 200 ppm accuracy, limited by the mean field systematic. We analyze the complete effect of the mean field interaction by numerically simulating the experiment using the nonlinear Gross-Pitaevskii equation. Together with this analysis we will also present our plans to extend the experimental technique to ytterbium BECs to achieve part-per-billion (ppb) level sensitivity. A measurement of the photon recoil at this level will provide a new competitive measurement of the fine structure constant ? at the sub-ppb level. This work is supported by the National Science Foundation. [1] S. Gupta et al, Phys Rev Lett 89, 140401 (2002)

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