Schroedinger Cat Atomic Interferometry at Decillion Hz Compton Frequency: Ultraprecise Gyroscopes, Accelerometers and Clocks

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Abstract

Optical interferometers, such as those used for rotation sensing and gravitational wave detection, are among the most precise metrological devices. This is due to the high frequency of lasers: ~$5*10^{14}$ Hz. In this talk, I will describe how interferometry at a frequency that is nearly nineteen orders of magnitude higher than this can be carried out by accessing the Compton Frequency (CF) of an ensemble of a hundred million atoms acting as a single particle. To reach this condition, an ensemble of Rb atoms are cooled in a magneto-optic trap. Each atom is then split into spin-up and spin-down states, followed by interaction with a detuned probe beam in a cavity, which produces one axis twist spin-squeezing. When the squeezing interaction is tuned to a critical value, the ensemble becomes a Schroedinger-Cat (SC) state, as a superposition of two collective states: one where all atoms are spin-down and another where all atoms are spin-up. For N atoms in the ensemble, each of these collective states has a CF of Nmc^2/h, where m is the mass of each atom. For $N=10^8$, the CF is ~2 decillion (10^{33}) Hz. I will describe how to realize ultra-precise gyroscopes, accelerometers and clocks using this SC-state of atoms.

Short Biography

Dr. Selim Shahriar is a Professor in the Department of Electrical Engineering and Computer Science, and in the Department of Physics and Astronomy at Northwestern University. He is also the Director of the Solid State and Photonics Research Interest Group within EECS, and a council member of the LIGO Scientific Collaboration. He is the founder and the chairman of the board of directors of Digital Optics Technologies, a company specializing in developing precision optical and atomic sensors. He received his Ph.D. from MIT in 1992. He has published 512 papers, including 209 in peer-reviewed journals. His work has been cited nearly 18000 times; he has 32 papers with more than 100 citations each, an H-index of 53, and an i-10 index of 152. His research interests include Applications of Slow and Fast Light, Quantum Computing with Trapped Atoms, Gravitational Wave Detection, Tests of General Relativity, Holographic and Polarimetric Image Processing, Atomic Clocks, Atom Interferometry, and Spin Squeezing. In 2016, for his contribution to the first detection of gravitational waves, he was a co-recipient of the Gruber Prize in Cosmology and the Special Breakthrough Prize in Fundamental Physics. He is a Fellow of SPIE and OSA.