Exotic Quantum States of Atoms for Precision Metrology: Subluminal Lasers, Superluminal Lasers and Schroedinger Cats

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Abstract

Engineered quantum states of atoms can have exotic properties that can be tailored to produce extremely sensitive sensors. In this talk, I will describe two types of such states. In the first type, all atoms in a vapor cell are placed in a quantum state where the electron and nuclear spin in each atom are aligned or anti-aligned. When these atoms are dressed with a laser highly detuned from an optical transition, the resulting system produces a highly dispersive gain. When placed inside a cavity, this system produces the subluminal/superluminal laser, with a group velocity smaller/larger than the vacuum speed of light by a factor as large as a million. Such a laser is extremely insensitive/sensitive to variations in the cavity length. Applications of the subluminal laser include extremely precise optical clocks and search for dark matter. Application of the superluminal laser include ultrasensitive gyroscopes. In the second type, a maximally entangled Schroedinger cat state of cold atoms is produced via the process of spin squeezing. In addition to applications in precision time keeping and rotating sensing, this state can be used to seek violation of the equivalence principle via dual species atom interferometry, at a level that is six orders of magnitude better than the current limit.

Short Biography

Dr. Selim Shahriar is a Professor in the Department of Electrical and Computer Engineering and the Department of Physics and Astronomy at Northwestern University. He is also the Director of the Solid-State, Photonics and Quantum Technologies Division within ECE. 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 693 papers, including 326 in peer-reviewed journals. His work has been cited more than 100,000 times; he has 105 papers with more than 100 citations each, an H-index of 102, and an i-10 index of 269. 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 Optica (formerly OSA).