A simple and versatile detection technique for cold atoms

G.Drougkakis[1,], **S.Pandey**[1], **G.Vasilakis**[1], and **Wolf von Klitzing** [1]

1 IESL/FORTH

Presenting author: G.Drougkakis, email:drougakis@iesl.forth.gr
* Corresponding author: Wolf von Klitzing, email:wvk@iesl.forth.gr

ABSTRACT

Ultracold atoms have demonstrated great prospects for both technological and fundamental science applications. In order to fully exploit their potential, a precise control of the atomic cloud that can manipulate the quantum features and harness quantum resources is required. We report a robust method for measurement and control of the atom number in an ultracold atomic ensemble. The measurement is based on the Faraday paramagnetic effect: off-resonant light, when traveling through a polarized atomic cloud, experiences optical rotation at an angle that is proportional to the number of atoms. The proposed measurement does not destroy quantum coherences and has an insignificant effect on the atomic temperature, so that it can be used to perform quantum-enhanced measurements and prepare the atomic state at the start of an interferometer sequence. Control of the atom number is realized by the unavoidable atom-loss that is introduced by the measurement, since even far off-resonant light has a non-zero probability for absorption. This atom-loss mechanism will be employed to shrink an initial ensemble to the targeted size. With the proposed method, for the first time the quantum back-action of the measurement probe is exploited to improve the stability of the experiment. Measuring with subatom-shot noise resolution will lead to number squeezed states of Bose Einstein Condensates and will pave the way for squeezing and entanglement generation for spectroscopy and interferometry. Preliminary results with a smaller than 1% precision in controling the atom number has been achieved using this method and will be presented. Applications of the proposed research include atomic clocks, inertial sensors, quantum computing, quantum simulations and fundamental physics experiments such as gravitational detectors.