All-optical trapping and QND measurement induced atomic spin squeezing in a cavity.

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Cold atom interferometry has demonstrated state of the art performance for the measurement of tiny rotations, accelerations and time. The sensitivity of atom interferometers already reached the atomic shot noise level. This limit can be overcome with the use of non-classical atomic states such as squeezed states. In this context, we investigate the generation of atomic spin-squeezed states by quantum non-demolition (QND) measurements in a high-finesse optical cavity.

We developed a crossed high-finesse cavity resonating both at 1560 nm and 780 nm. Laser light at 1560 nm injected in the cavity generates a far off resonance optical dipole trap where ^{87}Rb cold atoms are loaded from a magneto-optical trap. The geometry of the transverse optical modes were characterized with in-situ light-shift tomography [1]. Current work is done to reach the quantum degeneracy in the fundamental mode of the cavity.

The QND measurement is performed with a heterodyne detection scheme strongly immune to noise and which probes the atomic population difference of two hyperfine states of ^{87}Rb. The destructivity of this non demolition probe has been studied in free space and this tool has been applied to follow in real time the state of atomic interferometers. We developed a theoretical model to describe the spin-squeezing dynamics of the atomic state, which results from the non-linear back-action of the heterodyne measurement [2].

[1] J. P. Brantut, J. F. Clement, M. Robert de Saint Vincent, G. Varoquaux, R. A. Nyman, A. Aspect, T. Bourdel, and P. Bouyer. *Light-shift tomography in an optical-dipole trap for neutral atoms.* Phys. Rev. A **78**, 031401R (2008).

[2] T. Vanderbruggen, S. Bernon, A. Bertoldi, A. Landragin and P. Bouyer. *Spin-squeezing and Dicke state preparation through single-photon heterodyne measurement* arXiv:1003.0157 [quant-ph] (2010)