A novel experiment for coupling quantum gases to crossed optical cavities

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We present the current status of an experiment coupling quantum degenerate gas to various optical cavities. The key element is an interchangeable science platform, which can house any type of cavity combined with a lens for high-resolution imaging of the atoms. The platform is put into a loadlock chamber, from which it is transferred into a vibration-isolated docking station in the science chamber where it is electrically and thermally connected. A Bose-Einstein condensate will be generated from a cloud of laser-cooled 87-Rb atoms. We will first load the atoms into a hybrid trap [1] and then optically transport to the position of the cavity mode. Final optical evaporation will cool down the atoms to quantum degeneracy. The initial platform contains the cavities which are designed to cross at a 60 degree angle. The cavity mirrors are aimed to approach by tightly milling down their substrates such that we achieve the single-atom strong coupling regime $(g, \kappa, \gamma) = 2\pi(3, 0.1, 3)$ MHz. The design also allows optical access to image the atoms with an in vacuo aspheric lens of high numerical aperture. We aim to study various quantum many-body physics, such as triangular and hexagonal lattices with long-range interaction [2], nondestructive probing of the Mott-insulator to superfluid transition [3], and frustration in multimode cavities [4].

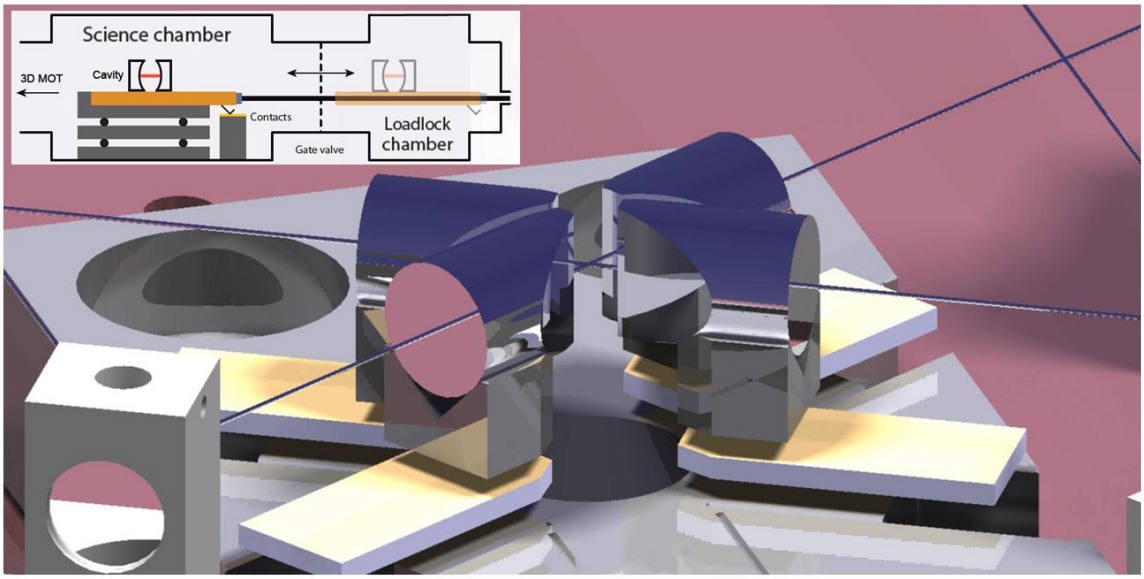

Fig.1. Design of the crossed cavities. (Inset) Scheme of the cavity transfer system.

References:
[1] Y.-J. Lin *et al.*, Phys. Rev. A. **79**, 063631 (2009).
[2] K. Baumann *et al.*, Nature **464**, 1301 (2010).
[3] I. B. Mekhov *et al* , Nat. Phy. **3**, 319 (2007).
[4] S. Gopalakrishnan *et al.*, Nat. Phy. **5**, 845 (2009).