Experimental internship / PhD Position - 2017/2018

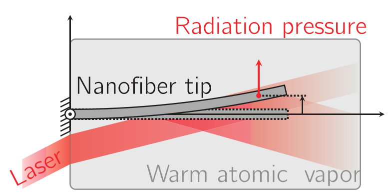
Opto-mechanical signature of light superfluidity

Quantum fluids of light

Most work in many body-physics (theoretical and experimental) are dealing with massive material particules (atoms, electrons...). However, we know since the early days of quantum mechanics that photons in a box can be interpreted as a massless Bose gas of non-interacting particules and this interpretation leads to a correct calculation of the black-body radiation. Recently, it has been realized that, under suitable circumstances, photons can acquire an effective mass and will behave as a quantum fluid of light with photon-photon interactions. Striking experimental demonstrations of superfluidity and other quantum hydrodynamics effects such as quantized vortices and solitons have been performed using semi-conductor planar micro-cavities. Building on these experiments done by the LKB group, we propose to use a different geometry (propagating light instead of confined) to study quantum fluids of light.

Internship

We will address a new way of testing light superfluidity by studying the drag force that a photon fluid exerts on a mobile obstacle. This experiment is based on a movable defect, a nanofiber, immersed in an atomic vapor so that the refractive-index mismatch provides a constant potential. A light beam hitting the nanofiber tip at a small angle, will create a flow around the impurity, or in optics language, a radiation pressure force resulting in the opto-mechanical deformation of the obstacle. We expect to observe a cancellation of this “optical drag force” at high intensity indicating a superfluid flow of photons around the obstacle. In terms of optics, this leads to a non-intuitive cancellation of the radiation pressure thanks to non-linear interactions.



We are currently building a setup to detect with very high precision (about 20 nm) the position of the nanofiber. By monitoring the position of the nanofiber, we will measure the small radiation pressure force exerted by a laser beam on the nano-object. First, we are going to perform preliminary measurements with light propagating in air (linear medium). In this condition, the radiation pressure force should be an increasing function of the incident laser power. The second step of the project will be to immerse the nanofiber in an atomic vapor. When light propagates through this nonlinear medium, it becomes superfluid above a critical laser power (i.e. above a critical photon density). In that case, we will measure the force acting on the the nanofiber as a function of the incident laser power. Contrary to air, we expect that, above a critical value of the intensity, the force is going to vanish, revealing the superfluid nature of light.

Interested candidates should contact Quentin Glorieux (quentin.glorieux@lkb.upmc.fr) and Alberto Bramati (bramati@lkb.upmc.fr). For more details, please check our website: www.quantumoptics.fr.