université de BORDEAUX

LOMA UMR5798 Laboratoire Ondes et Matière d'Aquitaine

Master 2 Internship

Title: Experimental realization of quantum-squeezed states of light using optically-levitated nano-objects.

Type: Experimental

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PhD funding (if any): PhD funding available

Project: **Optical levitation is a subfield of optomechanics**, in which a nanometer-size particle is trapped in a vacuum chamber at the focal spot of a laser focused through a microscope objective [1]. The laser beam produces an optical force equivalent to a mechanical spring and the system can be regarded as a simple mass-spring resonator displaying pristine vibrational oscillations in the kHz regime. Because levitated systems outperform other types of mechanical resonators, they are currently exploited to achieve high-sensitivity metrology, detect gravitational waves or search for dark matter. Yet, despite their simplicity, levitated systems provide a remarkable interaction between the mechanical motion of the particle and the light field, which can be harnessed to **generate quantum properties**.

Ponderomotive squeezing, also known as the **mechanically-assisted quantum squeezing of light**, provides an interesting illustration of such a property. Here, the intensity fluctuations of the optical field produce small displacements of the particle, which in turn modulate the phase of the photons that are reflected back from the nano-object. Therefore, one induces a correlation between intensity and phase fluctuations onto the reflected optical field that give rise to **quantum-squeezed states of light** (i.e., with an uncertainty below that of “classical” states). Achieved here on an extremely simple configuration, such squeezed states are of formidable importance to perform measurements **below the standard quantum limit** (and especially looked after in environments like the LIGO/VIRGO gravitational waves platforms). Yet, despite early demonstrations [2,3], squeezing performances currently reported with levitated objects are **rather limited due to the moderate strength of the light-matter interaction** between the nano-object and the optical field.

In this internship, the candidate will **experimentally study how quantum squeezing can be improved through a spatial modulation of the optical field**. Using a spatial light modulator, the incoming light field will be spatially shaped to maximize the radiation pressure (i.e., optical force) exerted onto the nano-object [4] and thus bolster light-matter interaction and squeezing. The student will be closely guided by the advisor and will acquire both theoretical and experimental skills on **optomechanics, levitation, quantum optics and in spatial modulation techniques**. **A funding is available to continue and expand this internship through a PhD**.

[1] Millen *et al.*, Reports on Progress in Physics, 83(2), 026401.
[2] Magrini *et al.*, Physical Review Letters, 129(5), 053601.
[3] Militaru *et al.*, Physical Review Letters, 129(5), 053602.
[4] Hüpfl and Bachelard *et al.*, Physical Review Letters, 130(8), 083203.