INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire de physique des lasers
CNRS identification code: UMR 7538
Internship director'surname: Laurent Longchambon and Hélène Perrin
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Internship location: Paris-Nord (Villetaneuse)

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: international ANR (coll. with Brazil)

Superfluid Bose-Einstein condensates in bubble traps

Context: Gases of ultracold atoms constitute one of the most fascinating quantum systems currently available in the laboratory. Particularly well-controlled quantum systems, they enable atomic physics predictions to be studied with unrivaled precision. Their applications include metrology and the wider field of quantum technology, quantum information and quantum simulation.

The BEC group at LPL produces a superfluid degenerate bosonic gas confined in a bubble-like potential obtained by a combination of static magnetic fields and a radio-frequency (rf) field [1]. The bubble-shape of the trap allowed us to explore different geometries like two-dimensional trapping [2], ring geometries [3,4,5] and curved traps [5]. We have developed tools to excite the system, either by magnetic/rf control [3,4,5], or by optical tools such as an optical laser spoon capable of creating a local perturbation of the quantum gas [4]. These tools enable us to rotate the condensate to study superfluid properties or dynamically alter the landscape as seen by the atoms, so as to put them out of equilibrium. We currently optimize a non-destructive technique to follow in real-time the superfluid dynamics.

Internship: In order to increase the imaging setup resolution and be able to see smaller details like vortices in the density excitations, we intend to use a 421 nm laser resonant with the 5S→6P line of rubidium instead of the widely used 780 nm 5S→5P transition. The main goal of the internship will be to be part of the design and mounting of this new optical setup onto the experiment, including a saturated absorption setup to lock the laser on the required frequency, fiber coupling and a remote control of the fast switching of the laser intensity by means of an acousto-optic modulator. The student will acquire know-how on an ultra-cold atom experiment and benefit from stimulating interaction with the larger ultra-cold atom group of around 15 people including four other experiments plus a theorist. Our group is a member of QuanTiP, a leading network of research groups in the Paris region in the field of quantum technologies.

Methods and techniques: Radiofrequency fields dynamical control, optics, image acquisition and analysis, atoms cooling and trapping. University education in quantum physics, atomic physics (e.g. atom-light interaction), lasers / optics is expected.

Thesis: The internship can be followed by a PhD funded by an ANR international grant, focused on the dynamics and out-of-equilibrium properties of a superfluid condensate, taking advantage of the rich possibilities of the bubble geometry (curvature, possibility to generate rings).

[1] B. Garraway and H. Perrin 2016 J. Phys. B. 49 172001
[2] K. Merloti et al 2013 New J. Phys. 15 033007
[3] Y. Guo et al, Phys. Rev. Lett. 124, 025301
[4] M. de Goër et al 2021 J. Phys.B 54 125302
[5] Y. Guo et al 2022 New J. Phys. 24 093040
[6] R. Sharma et al 2024, Phys. Rev. Lett. 133, 143401

Please, indicate which specialty(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES
Soft Matter and Biological Physics: NO
Quantum Physics: YES
Theoretical Physics: NO