Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire de physique des lasers
CNRS identification code: UMR 7538
Internship director'surname: Romain Dubessy and Hélène Perrin
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Internship location: 99 av JB Clément 93430 Villetaneuse (Paris Region)

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ED contract (guaranteed)

Stability of a supersonic superfluid

Quantum gases are one of the most fascinating quantum systems now available in the lab. Far beyond atomic physics, their applications include quantum metrology, superfluidity, quantum information and quantum simulation in the wider and developing frame of quantum technology.

In this context, the BEC group at Laser Physics Laboratory has developed a rubidium Bose-Einstein condensation experiment. This experimental setup produces a superfluid degenerate bosonic gas confined in a « bubble-like » potential obtained by a combination of magnetic and radiofrequency fields. Initially, the atoms occupy the bottom of this bubble, in a flat 2D geometry. We have developed tools to excite the system, either by means of magnetic/radio-frequency control, or with optical tools like an optical laser stirrer able to create a local perturbation of the quantum gas. These tools allow us to set the superfluid into rotation, and also modify dynamically the landscape seen by the atoms in order to put them out of equilibrium. In particular, we have prepared a fast rotating superfluid flow in the bubble: due to the centrifugal force, the gas climbs along the side of the bubble and takes a circular shape away from the bottom. In this way, we are able to bring the superfluid to very fast rotations rates, with supersonic speeds reaching Mach 18 i.e. 18 times the speed of sound in the gas [1]. This superfluid flow persists for about one minute in the rotationally invariant bubble trap.

[1] Supersonic rotation of a superfluid: a long-lived dynamical ring Y. Guo, R. Dubessy, M. de Goër de Herve, A. Kumar, T. Badr, A. Perrin, L. Longchambon, and H. Perrin Phys. Rev. Lett. 124, 025301 (2020)

The subject of the internship is to probe the stability of this fast flow and to study the eventual decay mechanisms. To this aim, we will add a local obstacle produced with the laser stirrer and study the decay of rotation as a function of the laser parameters (position, intensity). Many interesting phenomena are expected to occur, such as shock waves and turbulence.

The student will participate in the various steps of the experiment, from running the experiment to the data analysis, and will acquire good knowledge of state-of-the-art atomic physics. He/she will work within the BEC group, and will benefit from stimulating interaction with the larger ultra cold atom group of about fifteen people, including three other ultra cold atom experiments and a theory group. We also collaborate closely with M. Olshanii (U-Mass, Boston) , B. Garraway (Sussex University) and V. Bagnato (Sao Paulo University). Our group is a member of SIRTEQ, a world-leading joint institute gathering all the groups in Paris area in the field of quantum technology.

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