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

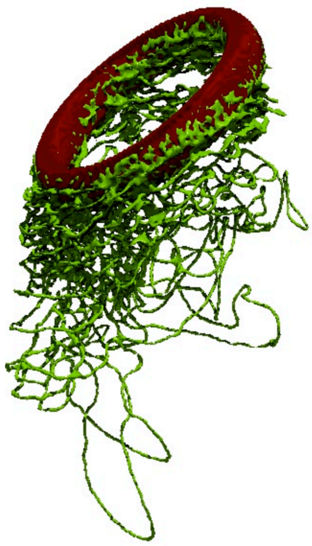
INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: J. L. Lagrange
CNRS identification code: UMR7293
Internship director'surname: G. Krstulovic
e-mail:krstulovic@oca.eu Phone number: 04 92 00 39 76
Web page: https://gkrstulovic.gitlab.io/
Internship location: Laboratoire Lagrange, Observatoire de la Côte d'Azur, Nice.

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Vortex nucleation in quantum fluids



Vortex nucleation in the wake of an accelerated solid ring. Quantum vortices are the green filaments, and the object is displayed in red.

A superfluid is a liquid distinguished from a classical fluid by the absence of molecular viscosity. Such a peculiar and surprising property originates in quantum mechanics and manifests at very low temperatures. The most common examples of superfluids are helium at temperatures below 2.17K and Bose-Einstein condensates.

When an object moves at a low velocity in a superfluid, it experiences no drag, making the superfluid akin to a perfect fluid. However, superfluidity breaks down if the object exceeds a critical velocity, and the object will perturb the fluid, creating excitations, such as quantum vortices. Such vortices are like atomic tornados, with quantised circulation, and behave as hydrodynamic vortices, reconnecting and rearranging their topology. Their existence is the most manifest quantum effect in superfluids.

Quantum vortices can be nucleated behind sufficiently fast-moving objects. When the geometry of the object is non-trivial or when the object is accelerated, they create very complex quantum vortex structures in its wake, as displayed in the figure.

This master project aims to study how vortices are nucleated in the wake of complex and accelerated objects and determine the wake's properties. We will also study the dynamics of falling free objects. The problem will be addressed by performing numerical simulations of the Gross-Pitaevskii model using the code already developed in the group. In the long term, for a thesis project, we will study how vortex nucleation close to a wall could lead to turbulence.

Please, indicate which speciality(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: YES