

Master 2 internship

Vortex nucleation in quantum fluids

Institution: Laboratoire J.L. Lagrange. Observatoire de la Côte d'Azur. Nice, France.

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Possible Ph. D thesis after internship: YES

Funding provided : NO

The project:

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.



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

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.

Applicant profile:

Applicants should have a good background in fluid mechanics and numerical methods. After the master internship completion, the successful applicant is expected to have learned about superfluids, vortex dynamics, turbulence and the basics of computation fluid dynamics.