Master internship

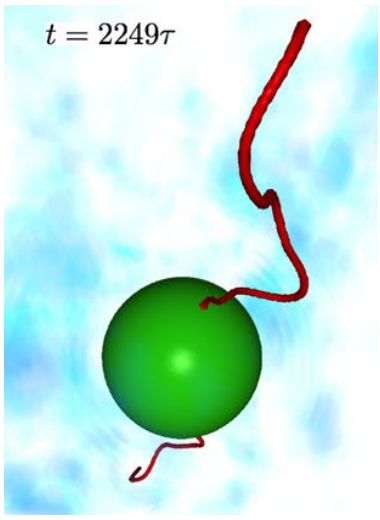
Motion of particles trapped in superfluid vortices

Duration: flexible
Institution: Laboratoire J.L. Lagrange. Observatoire de la Côte d'Azur. Nice, France.
Funding provided by: ANR GIANTE
Contact: Giorgio Krstulovic (https://www.oca.eu/fr/giorgio-krstulovic)
Deadline for application: open

The project:

Superfluidity is a fascinating and exotic state of matter that originates because the coexistence of classical and quantum effects at very low temperatures. A superfluid is a liquid distinguished from a classical fluid essentially by the absence of molecular viscosity. The main consequence is that an object that moves through it at low velocity does not experience any drag. Examples of superfluids are ^{3}He and ^{4}He, Bose-Einstein condensates (BEC) made of dilute alkaline gases, light in optical non-linear systems and the core of neutron stars. The applications of superfluids range from cooling superconducting materials and infrared detectors, to pure fundamental research in cold atoms and turbulence. The most manifest quantum effect in superfluid turbulence is the presence of quantum vortices. Such vortices are like atomic tornados, with a circulation that is quantised. In systems such as ^{3}He and ^{4}He and atomic BECs, quantum vortices behave as hydrodynamic vortices, reconnecting and rearranging their topology, creating in this way complex vortex tangles.

Over the last decades, thanks to the development of new experimental techniques, particles and impurities have been successfully used in superfluids to visualise quantum vortices. Such particles get trapped by the vortices and interact in a highly non trivial manner. They excite waves on the vortices that then act back on the particle. A typical visualisation of such configuration is shown in the image.



A particle (in green) trapped by a quantum vortex (in red) simulated by the Gross-Pitaevskii model.

This master project aims at understanding the dynamics of trapped particles in superfluid vortices and how they excite waves on the vortices. This problem will help to understand the dynamics of such objects in current experiments with superfluids. The problem will be addressed numerically in the framework of the Gross-Pitaevskii model in order to test some preliminary theoretical predictions. The successful applicant will use and modify the existent numerical codes already developed in the team. The project will be carried on in collaboration with Gustavo Düring from Pontificia Universidad Católica de Chile.

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 and particle dynamics and to develop skills on numerical methods and data analysis.

Research environment:

The successful applicant will join the ANR GIANTE project led by Giorgio Krstulovic, a CNRS researcher at the Fluid and Plasma Turbulence group of Laboratoire J.L. Lagrange hosted by Observatoire de la Côte d'Azur (https://www.oca.eu/en/fluid-home). The group is composed of experts in classical and quantum turbulence, magnethodrodynamics, wave turbulence, plasmas, particle transport, applied mathematics and computational fluid dynamics.

Enquiries and Application Process

To apply for this master project or further discussion, please contact Giorgio Krstulovic (krstulovic_at_oca.eu) in the first instance. You may then be asked to provide complementary documentation.

Please visit the webpage of the ANR GIANTE for other possible internships.
https://gkrstulovic.gitlab.io