Master 2 “Photonics, Complex and Quantum Systems (PhoCQS)”: Research Training 2023-2024

Supervisor: Clément Hainaut

Topic: Out-of-equilibirum fluid-of-light

Out-of-equilibrium quantum gases in reduced dimension

Out-of-equilibrium quantum gases, especially in two dimension gives rise to complex questions due to the particular density of states and specific connectivity providing thermal and/or quantum fluctuations more importance than in 3-dimensional systems. A prominent example is the low-dimensional quantum turbulent behavior of quantum gases possessing complex microscopic dynamics through proliferation of interacting quantized vortices leading to various possibilities of energy redistribution at macroscales. The physical implications between the existence of microscopic behaviors of the vortices and the development of macroscopic turbulent cascade are still partially unknown and is matter of debate.

Another question important question is how spatio-temporal coherence is built in 2D out-of-equilibrium condensate. This topic is untimely linked to the famous BKT theory, explaining the establishment of quasi-long-range-order (equivalent to establishment of full spatial coherence) associated to proliferation of pairs of quantized vortices while passing through a topological phase transition.

In this project we aim at answering these questions by exploiting new experimental capabilities to explore out-of-equilibrium quantum gases both macroscopically and microscopically. It will be based on an experimental Exciton-Polariton platform associated to state-of-the-art low photon number ultrafast imaging technics that are assembled at PhLAM laboratory by Clément Hainaut in the group of Alberto Amo.

More specifically, for this project, experimental investigations will be done but also an important numerical part can be envisaged in order to guide and support experimental findings.

Key words: Out-of-equilibrium phase transition, Quantum Turbulence, 2D Bose gas