INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Laboratoire de Physique des Lasers, Atomes et Molécules (Lille)
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Internship location: Laboratoire PhLAM, Lille

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Phonon Lifetime and KPZ Scaling in Non-Equilibrium Bose Superfluids

This project focuses on understanding the long-time dynamics of Bose gases driven out of equilibrium, a fundamental challenge in quantum many-body physics. When such gases are quenched within their superfluid phase, the relaxation dynamics, governed by phononic excitations, may exhibit universal scaling behavior described by the Kardar-Parisi-Zhang (KPZ) equation. However, uncertainties about the phonon lifetime in low-dimensional systems remain, where standard perturbative methods are inadequate. This project aims to develop a non-perturbative framework using the Functional Renormalization Group (FRG) to derive the phonon lifetime in 1D and 2D Bose superfluids, clarifying the KPZ conjecture in 1D and generating novel predictions for 2D systems.

The student will begin by learning the FRG method and its application to close-to and out of -equilibrium quantum systems, deriving the phonon scattering rate and analyzing its scaling behavior. The results will be benchmarked against numerical simulations and existing theories to validate the approach and refine the theoretical understanding of phonon dynamics. If time allows, the project will explore the connection between phonon lifetime scaling and the KPZ universality class, comparing FRG-derived results with experimental data.

Expected outcomes include a non-perturbative description of the phonon lifetime, clarification of the KPZ scaling in 1D, and new predictions for 2D superfluids. This project, which may extend into a PhD thesis, offers the opportunity to work at the forefront of quantum field theory and non-equilibrium physics, with potential applications in quantum technologies.

This project is in collaboration with the theory group of Nicolas Cherroret at Laboratoire Kastler-Brossel, Sorbonne Université.

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