INTERNSHIP PROPOSAL

Laboratory name: Laboratoire Kastler Brossel (LKB, UMR 8552)
Internship supervisor: Nicolas Cherroret
E-mail: nicolas.cherroret@lkb.upmc.fr
Web page: https://www.lkb.fr/quantumtheory/
Internship location: Campus de Sorbonne Université, Paris
Thesis possibility after internship: Yes
Possible PhD fundings: Quantedu/AMX/CDSN/ANR

Non-equilibrium dynamics and coarsening of supersolid Bose gases

Understanding how a many-body quantum system evolves after being abruptly driven out of equilibrium is a central challenge in statistical physics. Ultracold gases offer a unique testbed for probing this question, as quenches, i.e. sudden changes of a system parameter, can be implemented with remarkable control. When the quench brings the system into a phase that spontaneously breaks a symmetry, post-quench correlations may converge to a *non-thermal fixed point*, a non-equilibrium analogue to RG fixed points, characterized by time-dependent scaling laws governed by universal exponents that have no straightforward equilibrium counterpart (see, e.g., [1], and [2] for a recent work by our team).

Spin-orbit-coupled binary Bose gases, many-body systems combining spin-orbit and Rabi coupling, constitute a remarkable platform to explore this physics. Their zero-temperature phase diagram [3] hosts a standard superfluid phase, a 'plane-wave' phase and a 'stripe' phase. The latter is a genuine **supersolid**: a new phase of matter characterized by a superposition of plane waves that spontaneously breaks translational invariance while exhibiting superfluidity [4,5]. In the plane-wave phase, the gas instead picks a single momentum, breaking only the Z_2 symmetry.

This internship focuses on the non-equilibrium dynamics of this simpler plane-wave phase, as a first step before tackling the supersolid case. Extending an effective theory of domain coarsening [6] recently developed for binary gases, the goal is to derive scaling laws for the out-of-equilibrium correlations of the order parameter, and to determine the dynamical exponents of the associated non-thermal fixed point. The project will combine non-perturbative equations of motion in the dressed-state basis of the spin-orbit coupled mixture, stat-mech approaches to coarsening, and classical-field simulations. The internship will take place in the stimulating environment of LKB, in close contact with local theorists and experimental collaborators.

Opening towards a PhD: the internship naturally leads to a PhD on the **non-equilibrium dynamics of supersolid Bose gases**, possibly (but non-exclusively) addressing, depending on the taste of the candidate, (i) the formation and growth of supersolid domains, (ii) the quench dynamics beyond mean field using nonequilibrium quantum field theory, and (iii) possible realizations in quantum-fluid-of-light and ultracold-atom platforms, in connection with local experimental groups.

Collaborations:
Theory: CNR-Nanotec group (Lecce, Italy)
Experiment: LKB Quantum-fluids-of-light group (Paris)
Experiment: LKB BEC group (Paris)

References
[1] I. Chantesana, A. P. Orioli, T. Gasenzer, Phys. Rev. A 99, 043620 (2019)
[2] A. S. Bornens, E. Gliott, N. Cherroret, arXiv:2607.26620 (2026)
[3] Y. Li, L. P. Pitaevskii, S. Stringari, Phys. Rev. Lett. 108, 225301 (2012)
[4] J.-R. Li et al., Nature 543, 91 (2017)
[5] C. S. Chisholm et al., Science 391, 480 (2026)
[6] E. Gliott, C. Piekarski, N. Cherroret, Phys. Rev. Research 7, 033189 (2025)