Master 2: *Physics of complex systems*

INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: NO but we'll be supporting student for application @EDPIF

Correlations and temperature regimes in the one-dimensional Bose-Hubbard model

One-dimensional bosonic gases, despite being described by a simple Hamiltonian, display rich physics due to the fact that quantum and thermal fluctuations are particularly strong in such low-dimensional system and compete with strong interactions [1]. Furthermore, thanks to the existence of powerful one-dimensional analytical and numerical techniques and to many experimental realizations, they have become a playground for the study of quantum fluids, in particular out-of-equilibrium. While thermal regimes are well understood for bosons in the continuum (Lieb-Liniger model) [2] and are relevant to recent experiments [3], we would like to systematically understand them for bosons on the lattice (Bose-Hubbard model). This is motivated by recent experiments [4] and in particular by the development of a new setup at Institut d'Optique (IOGS), which offers the perspective of an active collaboration with the group of Marc Cheneau.

Using exact diagonalization, matrix-product state techniques and quantum Monte-Carlo, we wish to explore the different regimes of the Bose-Hubbard model from zero to high temperatures, and from weak to strong interactions. We aim at devising simple phenomenological laws by connecting them with the behavior of elementary quasiparticle excitations in the system [5]. This would prepare for a PhD extending and confronting these results to two-dimensions and out-of-equilibrium situations relevant for the IOGS experiment.

[1] M. A. Cazalilla, *et al*, Rev. Mod. Phys. **83**, 1405 (2011)
[2] D. S. Petrov, *et al,* Phys. Rev. Lett. **85**, 3745 (2000)
[3] Bess Fang, *et al*, Phys. Rev. Lett. **116**, 050402 (2016)
[4] Chiara D'Errico, *et al*, Phys. Rev. Lett. **113**, 095301 (2014)
[5] Guillaume Roux, *et al,* (2013) *New J. Phys.* **15** 055003

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