INTERNSHIP PROPOSAL

Laboratory name: CPHT
CNRS identification code: UMR 7644
Internship director'surname: Goutéraux
e-mail: blaise.gouteraux@polytechnique.edu Phone number: 0169334217
Web page: https://www.cpht.polytechnique.fr/?q=fr/node/323
Internship location: CPHT, Ecole Polytechnique, Palaiseau

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

From Boltzmann transport to hydrodynamics

In this doctoral project, we will study strongly-correlated Condensed Matter systems (such as cuprate high Tc superconductors) and the effective theories describing their low-energy dynamics. These are complicated systems for which no microscopic theory is available, or even an effective theory, such as Fermi liquid theory. Yet, a number of recent experimental thermoelectric studies on overdoped cuprates made some headway in reproducing their results using a Boltzmann equation approach to transport.

It is surprising that this should work, given the strongly-coupled nature of these materials. Boltzmann transport has a universal hydrodynamic regime, which can be derived in closed form in some cases. In this regime, only conservation laws for global symmetries are needed to describe the dynamics, instead of the Boltzmann equation for 1-particle distribution functions. Could it be that the experimental studies are in fact only probing this universal, hydrodynamic regime?

To answer this question, we will study the emergence of hydrodynamics from Boltzmann transport in a number of cases, starting from simple ones and moving on to more complicated ones closer to experiments, where the Fermi surface is no longer spherical and the collision kernel is not treated in the isotropic relaxation time approximation. We will include the effects of disorder, first in a homogeneous way via a relaxation time approximation, then in a more realistic way using inhomogeneous distribution functions. We will also move away from the relaxation time or semi-classical approximations by treating the collision kernel exactly or considering the Quantum Boltzmann Equation.

Some of these questions will give rise to collaborations with Gaël Grissonnanche (Irradiated Solids Lab, IPP) and with Joerg Schmalian (Karlsruhe Institute for Technology, Germany).

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: NO Theoretical Physics: YES