INTERNSHIP PROPOSAL

(One page maximum)

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: YES If YES, which type of funding:

Applications of gauge/gravity duality to quantum criticality and strange metals

Strange metals are a fascinating family of quantum materials, where charge transport differs considerably from Fermi liquid theory, the theory of conventional metals. Their resistivity scales linearly with temperature, while their frequency-dependent, ac conductivity shows frequency over temperature scaling. These are signatures of quantum criticality.

At a quantum critical point, temperature is the only scale, which is why physical observables are scaling. This is not quite what is observed in strange metals: indeed, their linear in temperature resistivity is in fact not compatible with the simplest version of quantum criticality, which would predict a constant resistivity. Thus, a scale has apparently not decoupled. Further, their ac conductivity shows a Drude peak centered at zero frequency, also in contradiction with simple quantum critical arguments. Put together, this phenomenology is suggestive of strong electronic interactions.

On the other hand, gauge/gravity duality is a first-principle framework to capture the dynamics of strongly-coupled states of matter. It originates from string theory, where it was discovered as a duality with a specific supersymmetric gauge theory. In the limit of infinite rank of the gauge group and large coupling, this gauge theory is dual to Einstein gravity coupled to a number of matter fields, in a higher number of spacetime dimensions. Thus, by solving the gravity equations, we can access the correlation functions of the dual field theory.

In this doctoral project, we will focus on holographic black hole spacetimes where the metric and the matter fields have special scaling properties near their horizon, and which are dual to unconventional, low or zero temperature critical states. We will investigate the spectrum of collective excitations in the complex frequency plane, and ascertain how they affect the ac conductivity at finite frequencies. We will also study nonlinear response and the time-dependent relaxation of currents far from equilibrium, and the effect of collective excitations on the return to equilibrium.

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