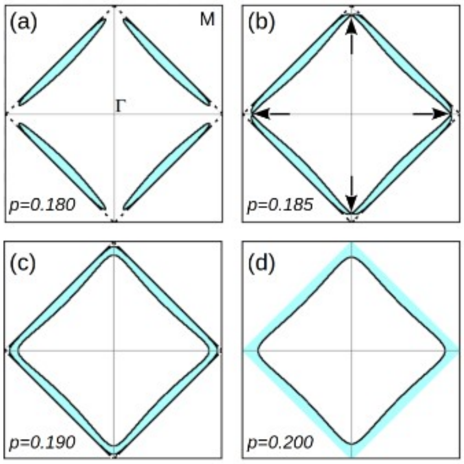
INTERNSHIP PROPOSAL

Laboratory name: MPQ Paris Cité / LPS Paris-Saclay
CNRS identification code: UMR 7162 / UMR 8502
Internship director'surname: Indranil Paul / Marcello Civelli
e-mail: ipaul.physics@gmail.com / marcello.civelli@universite-paris-saclay.fr
Phone number: 0157276247 / 0169156937
Web page: https://mpq.u-paris.fr/en/home/ https://www.lps.u-psud.fr/

Internship location: MPQ (Paris) & LPS (Orsay)
Thesis possibility after internship: YES
Funding: NO (Concours EDPIF)

Exceptional van Hoove singularities in cuprates



The change in the topology of electronic Fermi Surface known as Lifshitz transition is related to a diverging density of states, a van Hove singularity (VHS), crossing the Fermi level. These divergences can manifest themselves in response functions (like. e.g. specific heat or magnetic susceptibility) and can often trigger novel phases (like e.g. superconductivity). The role of the VHS has been often questioned for example in the context of high temperature superconductivity in cuprate oxides. In these systems, however, the electronic conduction takes place in two dimensional Cu-O planes, and for this case VHS is a weak logarithmic divergence. The real effects of the VHS on response functions and novel phases are then strongly diminished by small perturbations, like e.g. disorder.

In a recent work (https://arxiv.org/pdf/2210.01830.pdf), we pointed out that in correlated materials, like the aforementioned cuprates, the strong electronic interaction can drive the system to a new type of Lifshitz transition, where the VHS divergence is strongly enhanced with respect to the usual logarithmic one. We called this an "exceptional VHS" (EVHS). These facts rule the behavior of response functions close to a particular doping (p~ 0.20) where a mysterious unconventional metal phase, called the pseudogap, disappears. In this region, at the EVHS (p~0.185), quantities like specific heat show an unexpected and puzzling strong enhancement. This has been recently observed in key experiments on cuprates, but it has remained strongly debated, as specific compounds within the wide cuprate family display different behaviors.
Starting from our recent theoretical work, the task of this internship is to study the effect the specific electronic band structure of different cuprate compounds on the EVHS and to compare this with experimental results.

This internship work could develop into a thesis, where novel correlation-driven EVHS can be searched for in other quantum material systems, like heavy fermions, iron-based superconductors, organics, multi-layered graphene, to mention few. The thesis will take place within a MPQ (Paris Cité)-LPS (Paris-Saclay) collaboration.

Internship is financially supported. Thesis financial support must be obtained via the EDPIF doctorate fellowship or other source.

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