Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: LPS University Paris-Saclay (collaboration MPQ, Université de Paris), CNRS identification code: UMR 8503
Internship director'surname: Marcello **Civelli** (and Indranil **Paul**)
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Internship location: LPS (Plateau de Saclay) and MPQ (Paris 7)
Thesis possibility after internship: YES
Funding: YES Type of funding: grant Ecole Doctorale EDPIF

A New Age of Superconductivity

Superconductivity, the dissipation-less flow of charge, is one of the most fascinating macroscopic manifestations of quantum physics. A common belief is that superconductivity is nowadays an unfashionable well understood subject. Indeed, the early theory of superconductivity (BCS theory developed in the 50's) is one of the most successful theories of condensed matter physics. However, starting from the 80s, new series of superconductors, with constantly increasing transition temperatures (Tc), have marked new areas in a field that is fast evolving and full of surprises. We have already experienced the Ages of Copper, the Age Iron and the Age of Hydrogen and entering right now the Ages of Iridium, Carbon and Nickel[1]. This new superconductivity is not yet understood, and if room Tc can be reached, this would mark a turning point in our current technology, going from new quantum computing to train levitation.

Our theory group has a long experience in unconventional superconductivity in correlated materials, to which most of the superconductors mentioned above (Cu-Ir-Fe-C-Ni-based) belong to. We use quantum field theory tools, like Green's function methods and the dynamical mean field theory (implemented numerically), within an international network of collaborators (including USA, Canada, Brazil, Italy, India Japan) and in tight collaboration with experimentalists.

In this internship, we propose the student to start entering into this wide fascinating field by studying a particular problem, the Charge Density Wave (CDW) in Cu-oxide based superconductors, which are among the compounds with the highest Tc under normal conditions. This work is carried in tight collaboration with the experimental group of Alain Sacuto at the MPQ[2]. CDW is an exotic quantum phase appearing in these materials. Its role in determining the high Tc is currently questioned. Using a Green's function formalism the student will study this phase in a simple tight-binding model of Cu-based superconductors and try to account for properties observed in experiments performed by Alain Sacuto's group. This could be the starting point for a wider thesis subject, where more involved techniques and modeling will be employed. This internship is funded within an ANR grant.

Condensed Matter Physics:	YES	Soft Matter and Biological Physics:	NO
Quantum Physics:	YES	Theoretical Physics:	YES

1 https://physics.aps.org/articles/v13/85#:~:text=The%201986%20discovery%20that%20a,around%2030%20K%20%5B1%5D. This is a recent focus on the field.

2 https://www.nature.com/articles/s41567-019-0509-5