Proposition d’un Projet de Recherche en Laboratoire

Titre : Modern classical and quantum many-body approaches to strongly correlated quantum systems

Laboratoire d’accueil : CPHT, Collège de France, Paris

Résumé: Materials with strong electronic correlations are among the most interesting topics at the forefront research in physics. The reason for this is that they exhibit a vast variety of fascinating phenomena with a high potential for applications, but they still are poorly understood by theory.

One prototypical example is superconductivity, a pure quantum mechanism causing the electric resistance of a material to suddenly drop to zero upon cooling. In a certain class of superconductors, the so called cuprates, this transition from the metallic to the ideally conducting state can happen at temperatures of 135 K. This is quite remarkable as this temperature is above the boiling point of liquid nitrogen (78 K), resulting in this class of materials to be a perfect candidate for future technological applications. On the other hand, the theoretical description of these systems is so challenging that no consistent theory could be established since their first discovery in 1987.

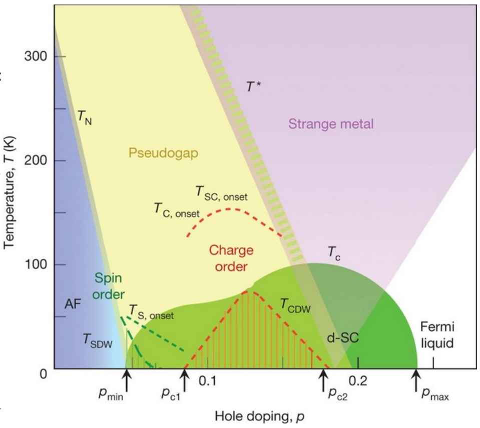

*Fig. taken from Keimer et al. Nature, **518**(7538):179–186 (2015)*

In this PRL, we will apply many-body techniques to study the properties and phase diagrams of prototypical models for strongly correlated systems using algorithms designed for classical computers and/or quantum computers. The student will first be introduced to the formalism of quantum field theory for condensed matter systems (second quantization, Green functions, Feynman diagrams). The next step will then be to learn about modern classical many-body approaches and algorithms such as the dynamical mean-field theory and diagrammatic Monte Carlo, and/or quantum algorithms to tackle such problems with quantum computers. These techniques will be used to gain insight into the physics of the Hubbard model defined on different lattice geometries. The main questions of interest are related to the competition between different charge- and magnetic-ordered phases.

Mots clés : Many-body quantum field theory, diagrammatic Monte Carlo, dynamical mean-field theory, strongly correlated quantum systems, quantum computing, cuprate superconductors

Nature : Théorique et numérique

Accueil d’un binôme possible : Oui

Personnes à contacter : Thomas Ayral (thomas.ayral@atos.net), Michel Ferrero (michel.ferrero@polytechnique.edu)