INTERNSHIP PROPOSAL

Laboratory name: Matériaux et Phénomènes Quantiques
CNRS identification code: UMR 7162
Internship director'surname: Yann Gallais
e-mail: yann.gallais@u-paris.fr Phone number: 01 57 27 69 89
Web page: https://mpq.u-paris.fr/squap/
Internship location: Bâtiment Condorcet, 10 rue Alice Domon et Léonie Duquet, 75013 Paris

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR-DFG grant

Manipulating unconventional superconducting states via anisotropic strain

Unconventional superconductors are a class of materials where electronic interactions are believed to play a key role in establishing the electron pairing responsible for the superconducting state. Among them the iron-based superconductors (Fe SC) have a rich phase diagram where superconductivity lies nearby, or even coexists, with other electronic ordered phase like anti-ferromagnetism and electron nematicity. A defining feature of Fe SC is the nearby degeneracy of SC ground states which can be distinguished by the symmetry properties of the ground state wave function such as s-wave and d-wave pairing state [1,2]. In particular, it has been predicted that the balance between SC ground states can be modified using anisotropic strain [3].

The close proximity of symmetry distinct SC states is expected to lead to a novel SC collective mode, predicted more than 60 years ago by Bardasis and Schrieffer (BS) [4]. This mode can be probed by optical spectroscopies such as inelastic Raman light scattering. The BS mode is a unique fingerprint of the energy balance between different SC ground states, and also of exotic SC states like the time-reversal symmetry breaking *s+id* wave state than can appear near the degeneracy point [5]. In this internship we propose to use uni-axial strain to induce a quantum phase transition between a *s-wave* and a *d-wave* SC ground state in the Fe SC $BaKFe_2As_2$. The quantum phase transition will be detected by tracking the evolution of the BS mode using low temperature Raman scattering combined with a piezo-based strain device. The internship is expected to be pursued into a PhD thesis under a collaborative ANR-DFG grant with the group of Anna Böhmer in Bochum (Germany).

[1] R. Fernandes et al. Nature, 601, 35 (2022)
[2] J. C. Philippe et al. Phys. Rev. Lett. 129, 187002 (2022)
[3] R. Fernandes and A. Millis, Phys. Rev. Lett. 111, 127001 (2013)
[4] A. Bardasis and J. Schrieffer, Phys. Rev. 121, 1050 (1961)
[5] Sarkar and Maiti, Phys. Rev. B **109**, 094515 (2024)

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: No