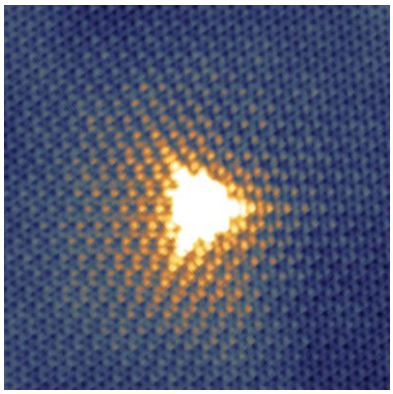
Master thesis Project

Probing the band structure of graphene-based topological 2D materials with quasiparticle interference.

STM Image of an hydrogen atom grafted at the surface of graphene. This shows typical quasiparticle interferences



Conducting electrons screen defects by forming an oscillation of local density of states around the defect. This phenomenon was uncovered by Jacques Friedel in the 1950's [1]. It is now known as quasiparticle interference since it can be understood as the interference between electronic waves hitting the defect and its reflection. The scanning tunneling microscope (STM) has allowed to visualize these oscillations in the real space and learn a lot about the Fermi surface of materials. Indeed, the quasiparticle interference has a period related to Fermi wavelength and the Fourier transform can allow to reconstruct the Fermi surface. The dispersion of the material can be deduced from a sequence of energy resolved local density of states maps measured by STM. A famous example is the parabolic dispersion of the 2D electron gas at the surface of copper [2] or the linear dispersion in Graphene [3].

We have recently shown that using quasiparticle interference one can also measure graphene's Berry phase [4,5]. This opens new possibilities to use quasiparticle interference to determine the topological properties of materials, which are difficult to measure by other means. The present research project aims at developing the technique and apply it to new graphene based materials like twisted bilayer graphene, superconducting graphene (induced by proximity), Rhombohedral graphene etc. The success will rely on the mastering of creating defects at the surface of graphene either by ion bombardment or hydrogen functionalization.

We are looking for a motivated Phd candidate with a strong background in condensed matter physics interested in low temperature scanning tunneling microscopy. The candidate will be involved in the project from sample preparation to the STM measurements and participate to a long term collaboration with Madrid University (Training in Madrid possible depending on the applicant.). The experimental work will be backed by theoretical input from the University of Bordeaux and Cergy Pontoise.

[1] J. Friedel Nuovo Cimento **7**, 287, (1958)
[2] M. Crommie t al. Nature **363**, 524 (1993)
[3] G. Rutter et al. Science **317**, 219 (2007)
[4] C. Dutreix et al. Nature **574**, 219 (2019)
[5] Y. Guan et al. ArXiv:2307.10024 (2023)

To apply for this position, send your application (including CV) by e-mail to :
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