M2 Internship/PhD offer

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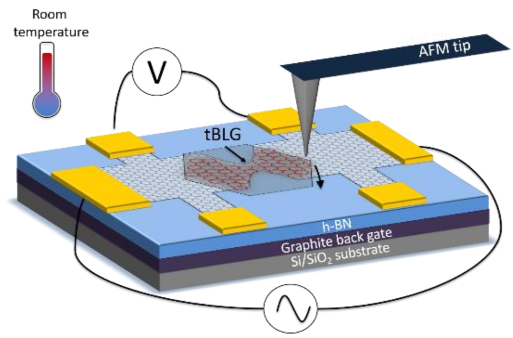
Superconductivity and topological states in twisted bilayer graphene

The first measurements of superconductivity and correlated phases in twisted bilayer graphene (tBLG) brought a lot of attention to this new way to control the properties of matter: twisting layers in a van der Waals heterostructure. The superconducting state in tBLG or twisted van der Waals structures is believed to have its origin in the interplay between the moiré superlattice and the interlayer interactions, which leads to the formation of a flat band in the electronic band structure. Controlling the twist angle between the layers allows playing with both of these parameters at the same time. As layers get more aligned, the moiré superlattice wavelength and the layer hybridization increases. However, as the two layers get more and more aligned, at angles >1.1°, the superconducting temperature decreases. A remarkable change of the critical superconducting temperature from 1.7 K to 0.5 K was reported for angular variations of 1.05 and 1.16 degrees in the case of tBLG [Cao et al., Nature 2018]. Given this astonishing result, we might wonder what is so special in the so-called magic-angle, 1.1 degrees and if other magic angles can be found where flat bands can be observed.

Up to now it seems that twisted bilayer graphene is the ideal playground for most of the condensed matter phenomena, from superconductivity to anomalous quantum Hall effect and other correlated phases. However, the most challenging part of this research seems to lay in a reliable fabrication of homogeneous samples. In our laboratory we have developed a new technique to continiously control the angular alignment between layers [Ribeiro et al., Science 2018].



During this internship (with the possibility to be extended for a PhD thesis) we will use the layer alignment technique combined with low temperature measurements of electron transport to reveal the phase diagram of the superconducting state and other strongly correlated effect. This phase diagram will allow us to understand the origin of the superconducting state as well as what are the parameters increasing the critical superconducting temperature.

Methods and techniques: Electron transport, low temperatures physics, micro and nano fabrication

Possibility to go on with a PhD ? Yes