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#ICMolTalks

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Room SS6

2D Materials a route for Quantum Technologies: from chiral carriers to hydrodynamics and much more!

Abstract

Two-dimensional (2D) crystals are particularly well suited for studying the interplay between symmetry and nonlinearity due to their high level of ordering. Remarkably, electronic states in these systems display quantum effects that give rise to novel and intriguing nonlinear effects simplifying further symmetry analysis.

In addition to the spin degeneracy, charge carriers in graphene have an additional degree of freedom called valley pseudospin. At the corners of the Brillouin zone (K and K' points), the electronic states on the two sublattices in pristine graphene are decoupled and have the same energy, giving rise to the so-called valley degeneracy. This degeneracy can be lifted, as for example, by stacking graphene with hexagonal boron nitride (hBN) and twisting properly the layers of the heterostructure leading to the appearance of an angle-dependent Moiré pattern. Such effect can break several symmetries and enhances collective interactions, providing the appearance of a plethora of exotic states of matter.We have fabricated several hBN/graphene/hBN heterostructures where the relative rotation angle between the flakes has been controlled and released on a graphite back gate placed over standard SiO2/Si substrates. We will present detailed local and non-local magneto-transport measurements at low-temperatures demonstrating the occurrence of exotic quantum edge states due to the angle-dependent Moiré pattern.10 Twisting the geometry of the graphene heterostructures it's also a must to observe hydrodynamic effects. We will present preliminary transports results of and anti-dots graphene superlattice showing superballistic behavior and some other signatures of viscous flow. Finally, we will revisited the room temperature quantum hall effect in graphene to address the enigma of why it could not be observed in high-quality graphene heterostructures. By this means, we extend the well-accepted notion of phonon-limited resistivity in ultra-clean graphene to a hitherto unexplored high-field realm.

References

1) D. Vaquero et al. Phonon-mediated room-temperature quantum Hall transport in graphene. Nature Communications 4.318 (2023). https://doi.org/10.1038/s41467-023-35986-3

2) J. Salvador-Sánchez et al. Generation and control of nonlocal chiral currents in graphene superlattices by orbital Hall effect https://link.aps.org/doi/10. 1103/PhysRevResearch.6.023212