SYIS 1: Interactions and Spins in 2D Heterostructures

Time: Thursday 15:00–17:45 Location: H1

Invited Talk SYIS 1.1 Thu 15:00 H1

Magic Angle Graphene: a New Platform for Strongly Correlated Physics — •Pablo Jarillo-Herrero — MIT, Cambridge, USA

The understanding of strongly-correlated quantum matter has challenged physicists for decades. Such difficulties have stimulated new research paradigms, such as ultra-cold atom lattices for simulating quantum materials. In this talk I will present a new platform to investigate strongly correlated physics, based on graphene moiré superlattices. In particular, I will show that when two graphene sheets are twisted by an angle close to the theoretically predicted *magic angle*, the resulting flat band structure near the Dirac point gives rise to a strongly-correlated electronic system. These flat bands exhibit half-filling insulating phases at zero magnetic field, which we show to be a correlated insulator arising from electrons localized in the moiré superlattice. Moreover, upon doping, we find electrically tunable superconductivity in this system, with many characteristics similar to high-temperature cuprates superconductivity. These unique properties of magic-angle twisted bilayer graphene open up a new playground for exotic many-body quantum phases in a 2D platform made of pure carbon and without magnetic field. The easy accessibility of the flat bands, the electrical tunability, and the bandwidth tunability though twist angle may pave the way towards more exotic correlated systems, such as quantum spin liquids or correlated topological insulators.

Invited Talk SYIS 1.2 Thu 15:30 H1

Bilayer Graphene Quantum Devices — •Klaus Ensslin — ETH Zurich, Switzerland

We demonstrate electronic constrictions on bilayer graphene that can be completely pinched off [1]. Split-gate devices in combination with a graphite backgates enable electronic tunability of the devices. In few electron and hole quantum dots confined by p-n junctions [2] we investigate valley and spin splitting. Also many electron quantum dots with standard tunneling barriers as well as double and triple quantum dots [3] can be realized with an electronic quality comparable to the best dots fabricated in standard semiconductor environments. The level spectrum of quantum point contacts in bilayer graphene has a peculiar magnetic field dependence quite different from what is known from semiconductors. We understand the details of this spectrum [4] based on the Berry curvature in bilayer graphene. These experiments open the door for using graphene quantum dots as spin qubits with potentially long coherence times. This work was done in collaboration with H. Overweg, M. Eich. R. Pisoni, Y. Lee, P. Rickhaus, A. Kurzmann, and T. Ihn,

References

1. H. Overweg, et al. Nano Lett. 18, 553 (2018)
2. M. Eich, et al. Phys. Rev. X 8, 031023 (2018)
3. M. Eich, et al. Nano Lett. 18, 5042 (2018)
4. H. Overweg, et al. arxiv:1809.01920 , PRL in print

Invited Talk SYIS 1.3 Thu 16:00 H1

Light-Matter interaction in van der Waals heterostructures — •Tobias Korn — Institut für Physik, Universität Rostock, Albert-Einstein-Straße 23 - 24, 18059 Rostock

In recent years, two-dimensional crystals and their van der Waals heterostructures have garnered a lot of attention. Their surprisingly strong interaction with light has been one of the key features in enabling the rapid growth of this research field, starting with the direct visibility of graphene in optical microscopy. Since then, optical spectroscopy has become an ideal probe for electronic structure, crystallographic alignment and interlayer interactions. In semiconducting two-dimensional crystals, such as transition-metal dichalcogenides, optical techniques give access to a variety of quasiparticles, such as excitons, trions and biexcitons, with peculiar properties due to the complex, multivalley band structure of the host material.

The combination of different two-dimensional crystals into van der Waals heterostructures has given rise to a novel form of quasiparticles, so-called interlayer excitons, in which the constituent electrons and holes are spatially separated into different layers. By designing the material combination and crystallographic alignment (twist angle) of the heterostructures, we can custom-tailor interlayer exciton properties, providing a highly interesting platform for basic research and potential optoelectronic applications.

15 min. break

Invited Talk SYIS 1.4 Thu 16:45 H1

Spin transport in Van der Waals materials and heterostructures — •Bart Van Wees — Nijenborgh 4.13 9747 AG Groningen

I will give an introduction into spin transport and spin dynamics in Van der Waals structures of (bi) layers of graphene and transition metal dichalcogenides (TMDs). In these systems the specific valley dependent spin structure of the TMD layer can be imprinted on the electron spins in the graphene by spin orbit proximity effect. As a result the spin relaxation times become anisotropic for in-plane and out-of-plane spins [1,2]. This can be studied by (nonlocal) spin transport techniques and spin precession experiments, showing modified anomalous Hanle precession curves. Recently we also observed manifestations of the Rashba Edelstein effect,as well as the spin Hall effect, resulting in in-plane and out-of-plane spin accumulations being generated by a charge current through the Van der Waals heterostructures [3]. I will discuss the relevance of these experiments for charge-spin and charge-spin-photon conversion devices. [1] T.S. Ghiasi et al., Nano Lett. 17, 7528 (2017) [2] J.C. Leutenantsmeyer at al., Phys. Rev. Lett. 121, 127702 (2018) [3] T.S. Ghiasi et al., in preparation

Invited Talk SYIS 1.5 Thu 17:15 H1

Flipping the valley in graphene quantum dots — •Markus Morgenstern — II. Institute of Physics B, RWTh Aachen University, 52074 Aachen

Graphene provides two extra binary degrees of freedom, - sublattice and valley -, dubbed pseudospins. They might offer additional possibilities for information processing.

Via low-temperature STM measurements, I will demonstrate the control of the valley pseudospin within an edgeless graphene quantum dot (QD) on BN. The QD is induced by the potential of the STM tip [1]. An external B field provides the required gaps by Landau quantization. As such, the QD can be moved freely across the graphene/BN sample. The laterally changing orientation of the C atoms with respect to B and N changes the valley splitting of the confined states continuously [2]. This eventually leads to an inversion, i.e., an individuial electron is flipped from one valley to the other.

Compelling evidence for the flipping process is provided by favorable quantitative comparison with calculations based on density functional theory.

Additionally, I will pinpoint to the control of the sublattice degree of freedom by huge pseudomagnetic fields (~1000 T) caused by the van-der Waals forces of the STM tip [3].

[1] N. Freitag et al., Nano Lett., 16, 5798 (2016). [2] N. Freitag et al., Nat. Nanotechnol. 13, 392(2018). [3] A. Georgi et al., Nano Lett., 17, 2240 (2017).