Symposium Transport in Graphene (SYTG)

jointly organized by
Semiconductor Physics Devision (HL), and
Dynamics and Statistical Physics Devision (DY)

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Overview of Invited Talks and Sessions

(lecture room BAR SCHÖ)

Invited Talks

SYTG 1.1	Tue	14:00–14:30	BAR SCHÖ	**The nature of localization in graphene under quantum Hall conditions** — •Jurgen Smet
SYTG 1.2	Tue	14:30–15:00	BAR SCHÖ	**Electronic Transport in Graphene Nanostructures** — •Thomas Ihn, Christoph Stampfer, Johannes Güttinger, Francoise Molitor, Stephan Schnez, Arnhild Jacobsen, Klaus Ensslin
SYTG 1.3	Tue	15:00–15:30	BAR SCHÖ	**Spins and valley-spins in graphene nanostructures** — •Inanc Adagideli
SYTG 1.4	Tue	15:30–16:00	BAR SCHÖ	**Theory of ballistic transport in graphene** — •Bjoern Trauzettel

Sessions

SYTG 1.1–1.4	Tue	14:00–16:00	BAR SCHÖ	**Symposium: Transport in Graphene**

SYTG 1: Symposium: Transport in Graphene

Time: Tuesday 14:00–16:00 Location: BAR SCHÖ

Invited Talk SYTG 1.1 Tue 14:00 BAR SCHÖ
The nature of localization in graphene under quantum Hall conditions — •Jurgen Smet — Max-Planck-Institut für Festkörperforschung

Particle localization is an essential ingredient in quantum Hall physics. In conventional high mobility two-dimensional electron systems Coulomb interactions were shown to compete with disorder and to play a central role in particle localization.

Here we address the nature of localization in graphene where the carrier mobility, quantifying the disorder, is two to four orders of magnitude smaller. We image the electronic density of states and the localized state spectrum of a graphene flake in the quantum Hall regime with a scanning single electron transistor. Our microscopic approach provides direct insight into the nature of localization. Surprisingly, despite strong disorder, our findings indicate that localization in graphene is not dominated by single particle physics, but rather by a competition between the underlying disorder potential and the repulsive Coulomb interaction responsible for screening.

This work was carried out together with J. Martin, N. Akerman, G. Ulbricht, T. Lohmann, K. von Klitzing and A. Yacoby.

Invited Talk SYTG 1.2 Tue 14:30 BAR SCHÖ
Electronic Transport in Graphene Nanostructures — •Thomas Ihn, Christoph Stampfer, Johannes Güttinger, Francoise Molitor, Stephan Schnez, Arnhild Jacobsen, and Klaus Ensslin — ETH Zurich, 8093 Zurich, Switzerland

Experimentalists have started to investigate effects of mesoscopic physics well known from experiments on GaAs, such as the quantum Hall effect, conductance quantization, the Aharonov-Bohm effect and the Coulomb blockade effect, in graphene. It is the goal of these investigations to find ways to confine charge carriers in this material system with its gapless band structure, to exploit the field effect for electrostatic control of electronic properties on the nanoscale, and to explore the feasibility of tailored quantum circuits for future electronics.

We will give an overview over experiments carried out in our team on narrow graphene constrictions and quantum dot devices at liquid Helium temperatures. These nanostructure systems, defined by electron beam lithographic techniques, are equipped with graphene in-plane gates for local electrostatic control. Our measurements demonstrate the interplay of lithographic confinement, interactions manifest in the appearance of the Coulomb blockade effect, and disorder, even in the simplest single constriction devices.

Despite the significant complexity of the physics in single constrictions, well controllable quantum dot devices exhibiting Coulomb blockade physics can be fabricated, and even on-chip charge detection techniques have been realized in our experiments.

Invited Talk SYTG 1.3 Tue 15:00 BAR SCHÖ
Spins and valley-spins in graphene nanostructures — •Inanc Adagideli — Universitaet Regensburg

In this talk, I will discuss spin and valley-spin dependent transport in graphene nanostructures particularly nanoribbons and quantum dots. First, I will focus on graphene nanoribbons and show how the states localized at their edges get magnetized and can be used for spin injection [1]. Furthermore, nanoribbons with rough edges exhibit spin conductance fluctuations with a universal value of $0.4e/4\pi$, when the localization length is comparable to the length of the ribbon. Next, I will focus on the graphene quantum dots and discuss the universalities featured by their spectra and conductance and how these properties depend on their edges[2]. Particularly if the confinement is due to abrupt lattice termination, these properties are well described by the standard orthogonal (unitary in the presence of magnetic field) ensemble of random matrix theory. However, if the confinement is due to a smooth mass boundary, the Hamiltonian is block diagonal in the valley degree of freedom and expected to feature time reversal symmetry breaking in the absence of magnetic fields. Although the effect of this structure is clearly visible in the conductance of open dots, it is suppressed in the spectral statistics of closed dots. I will conclude by describing a semiclassical theory of quantum transport in graphene nanostructures that qualitatively describes the spin and valley-spin dynamics as well as their universal effects on the quantum transport and energy spectra.

[1] M. Wimmer et al., Phys. Rev. Lett. 100, 177207 (2008)
[2] J. Wurm et al., arXiv:0808.1008v1

Invited Talk SYTG 1.4 Tue 15:30 BAR SCHÖ
Theory of ballistic transport in graphene — •Bjoern Trauzettel — Institut fuer Theoretische Physik und Astrophysik, Universitaet Wuerzburg

We explain the theory of ballistic transport in graphene using the scattering matrix formalism based on the Dirac equation. This approach allows calculating the conductance (or likewise the conductivity) as well as the current noise through graphene nanostructures. We put a strong emphasis on the temperature dependence of transport properties. We show that the conductivity σ at high temperature T and low electron density n grows linearly with T, while at low T and high n it follows $\sigma \propto \sqrt{|n|}$. Our results qualitatively agree with recently measured data on suspended graphene sheets.