TT 27: Symposium "Graphene"

Time: Thursday 14:00–16:40 Location: H20

Invited Talk TT 27.1 Thu 14:00 H20

Graphene: New bridge between condensed matter physics and QED — •Mikhail Katsnelson — Radboud Universiteit Nijmegen, Toernooiveld 1, Nijmegen, 6525 ED, THe Netherlands

Graphene, which is the first example of truly two-dimensional crystals (it's just one layer of carbon atoms) turns out to be gapless semiconductor with unique electronic properties resulting from the fact that charge carriers in graphene demonstrate charge-conjugation symmetry between electrons and holes and possess an internal degree of freedom similar to chirality of ultrarelativistic elementary particles. It provides unexpected bridge between condensed matter physics and quantum electrodynamics. In particular, the Klein paradox of relativistic quantum mechanics is of crucial importance for design of carbon-based transistors; vacuum polarization around charge impurities is essential to understand electron mobility; *index theorem* explains anomalous quantum Hall effect in graphene.

TT 27.2 Thu 14:30 H20

Magnetic confinement of massless Dirac fermions in graphene — A. De Martino, L. Dell Anna, •W. Häusler, and R. Egger — Heinrich-Heine-Universität Düsseldorf,*Institut für Theoretische Physik IV, Universitätsstraße*1, Gebäude 25.32, D-40225 Düsseldorf

Due to Klein tunneling, electrostatic potentials are unable to confine Dirac electrons. We discuss how to solve the corresponding Dirac equation for massless fermions, describing electrons in a monolayer of graphene, in the presence of various profiles of *inhomogeneous* magnetic fields. As a result, discrete electronic levels are obtained, similar as for the familiar electrostatic Schrödinger quantum dot.

TT 27.3 Thu 14:55 H20

Designing pencil traces for spintronics (SWITCHED WITH HL 49.1) — •Inanc Adagideli, Michael Wimmer, Savas Berber, Klaus Richter, and David Tomanek — Universität Regensburg, 93040 Regensburg, Germany

Monolayers of graphite have attracted much theoretical and experimental attention recently, owing to their nearly massless charge carriers and the internal spin-like degrees of freedom. We explore the use of conventional spin and spin-like degrees of freedom for spintronics in undoped and doped systems related to graphene. To this end we consider mono- and bi-layer strips consisting of sp^2 bonded carbon or BN and identify their electronic and spin-like degrees of freedom, corresponding to sublattice and valley degeneracy structure, using ab initio calculations. Based on quantum transport calculations, we determine how spin polarized currents could be generated, manipulated, and detected.

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Invited Talk TT 27.4 Thu 15:20 H20

Transport properties of mesoscopic graphene — •Björn Trauzettel — Department of Physics and Astronomy, University of Basel, CH-4056 Basel, Switzerland

Two recent experiments have discovered that the conductivity of graphene (a single atomic layer of carbon) tends to a minimum value of the order of the quantum unit e^2/h when the concentration of charge carriers tends to zero. This quantum-limited conductivity is an intrinsic property of two-dimensional Dirac fermions (massless excitations governed by a relativistic wave equation), which persists in an ideal crystal without any impurities. In the absence of impurity scattering, and at zero temperature, one might expect the electrical current to be noiseless. In contrast, we show that the minimum in the conductivity is associated with a maximum in the Fano factor (the ratio of noise power and mean current). The Fano factor at zero carrier concentration takes on the universal value 1/3 for a wide and short graphene strip. This is three times smaller than the Poissonian noise in a tunnel junction and identical to the value in a disordered metal. We discuss the relation of this result to the phenomenon of zitterbewegung which is present for free Dirac fermions but absent for free Schrödinger fermions.

Work done in collaboration with C.W.J. Beenakker, Ya.M. Blanter, A.F. Morpurgo, A. Rycerz, M. Titov, and J. Tworzydlo.

TT 27.5 Thu 15:50 H20

Scattering approach to disordered graphene — •Mikhail Titov — University of Konstanz, Theoretical Solid State Physics, Department of Physics, M703, D-78457 Konstanz, Germany

Low-energy charge excitations in graphene are described by the "relativistic"massless Dirac equation, which is behind many exotic transport phenomena observed in this material. The quasiparticle density of states in graphene vanishes at zero doping when the chemical potential coincides with the Dirac electron-hole degeneracy point. Nevertheless the experiments demonstrate that the conductivity at this point reaches a finite minimal value of the order of $4e^2/h$. Based on the scattering approach to the charge transport we provide a comprehensive description of the observed behaviour, which relies on the universal quasiparticle tunneling. We investigate the role of different types of disorder and conclude from comparison with experimental data that existing graphene samples possess a strong potential disorder, which is smooth on atomic scales.

TT 27.6 Thu 16:15 H20

Hofstadter butterflies of carbon nanotubes and graphitic structures (SWITCHED WITH HL 49.3) — •Norbert Nemec and Gianaurelio Cuniberti — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg

The electronic spectrum of a two-dimensional square lattice in a perpendicular magnetic field has become known as the Hofstadter butterfly [Hofstadter, Phys. Rev. B 14, 2239 (1976)]. We have calculated quasi-one-dimensional analogs of the Hofstadter butterfly for carbon nanotubes (CNTs) and graphene. Single-wall CNTs and graphene nanoribbons in perpendicular magnetic fields show a rich, pseudofractal spectrum, that can be related to the butterfly of planar graphene. In double-wall CNTs, the interlayer interaction adds modulations in the spectrum that can be understood by studying the effects of intense magnetic fields onto bilayer graphene which is per se an interesting material due to its anomalous quantum Hall effect that could recently be measured in experiment.