MA 54: Graphene: Bi- and multi-layers (with DY/DS/HL/O/TT)

Time: Friday 9:30–11:00 Location: POT 081

MA 54.1 Fri 9:30 POT 081

Atomistic simulations of dislocations in bilayer graphene — •Konstantin Weber[1], Christian Dolle[2], Florian Niekiel[2], Benjamin Butz[2], Erdmann Spieker[2], and Bernd Meyer[1] — [1]Interdisciplinary Center for Molecular Materials and Computer-Chemistry-Center, FAU Erlangen-Nürnberg — [2]Center for Nanoanalysis and Electron Microscopy, FAU Erlangen-Nürnberg

The atomic structure and the properties of basal-plane dislocations in bilayer graphene, the thinnest imaginable crystal that can host such 1D defects, has been investigated by atomistic simulations based on the registry-dependent potential of Kolmogorov and Crespi [1] and the classical AIREBO potential.
Our calculations show that the dislocations lead to a pronounced buckling of the graphene bilayers in order to release strain energy, leading to a complete delocalization of the residual compressive/tensile strain in the two graphene sheets [2]. Furthermore, the absence of a stacking-fault energy, a unique peculiarity of bilayer graphene, gives rise to a splitting of the dislocations into equidistant partials with alternating Burgers vectors [2]. Thus, dislocations in bilayer graphene show a distinctly different behavior than corresponding dislocations in graphite or other 3D crystals.

[1] A. Kolmogorov, V. Crespi, *Phys. Rev. B* **71**, 235415 (2005).
[2] B.Butz, C. Dolle, F. Niekiel, K. Weber, D. Waldmann, H.B. Weber, B. Meyer, E. Spieker, *Nature*, (2013) (accepted for publication).

MA 54.2 Fri 9:45 POT 081

Study of the magnetoresistance of biased graphene bilayers — •Dmitri Smirnov[1], Galina Y. Vasileva[1,2], Yurij B. Vasilyev[2], Pavel S. Alekseev[2], Yurij L. Ivanov[2], Hennrik Schmidt[1], Alexander W. Heine[1], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover — [2]Ioffe Physical Technical Institute, Russian Academy of Sciences, St. Petersburg

We demonstrate magnetotransport behaviour of bilayer graphene. In contrast to monolayer graphene, bilayer has a parabolic band structure with a zero band gap, which can be opened by applying an electrical field perpendicular to the samples [1]. One of the consequences of such a band structure is the coexistence of two different types of charge carriers with the Fermi energy placed near the charge neutrality point.

Several bilayer graphene samples with different electrical properties (charge neutrality point, mobility) have been investigated. A positive and negative magnetoresistance is observed for electrons and holes. We can show that that the positive magnetotransport can be described well with a two carrier Drude model which allows us a new approach to probe parameters of electrons and holes separately.

[1] McCann, E., and V. Fal'ko Phys. Rev. Lett. 96, 086805 (2006)

MA 54.3 Fri 10:00 POT 081

Transport in Dual Gated Encapsulated Bilayer Graphene — •Jonas Hesselmann[1], Stephan Engels[1,2], Bernat Terrés[1,2], Kenji Watanabe[3], Takashi Taniguchi[3], and Christoph Stampfer[1,2] — [1]JARA-FIT and II. Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — [3]National Institute for Materials Science, 1-1 Namiki, Tsukuba, 305-0044, Japan

Bilayer graphene (BLG) is a promising material which combines superior electronic properties like high charge carrier mobilities with the possibility of opening a band gap. The band gap can be induced by applying a perpendicular electric field resulting in a gap in the order of a few 10 meV. This makes BLG a possible candidate for future nanoelectronic applications. Here, we present the fabrication and low temperature (T=2K) transport measurements of dual gated BLG which is encapsulated in hexagonal boron nitride serving as an atomically flat gate dielectric. We show that the investigated devices exhibit mobilities of up to 80.000 cm^2/Vs. Quantum Hall effect measurements show a distinct sequence of Hall plateaus together with a full symmetry breaking of the eightfold degenerate zero Landau level. By temperature dependent measurements we investigate the energy gap opening as function of a perpendicular electric field. We find that the transport via localized states at low temperatures exhibits a strong asymmetric behavior with respect to the sign of the applied electric field while the temperature activated transport is fully symmetric.

MA 54.4 Fri 10:15 POT 081

An emergent momentum scale and low energy theory for the graphene twist bilayer. — •Sam Shallcross, Nicolas Ray, Dominik Weckbecker, and Oleg Pankratov — Theoretische Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7B2, 91058 Erlangen

We identify an angle dependent *momentum scale* as the fundamental property of a bilayer composed of mutually rotated graphene layers [1]. This leads to (i) a numerical method that increases, for the twist bilayer, the efficiency of the standard tight-binding method by a factor of $\approx 10^3$, at no loss of accuracy, and (ii) a low energy theory that can be deployed, without distinction, for both the low angle regime and the large angle regime. In the low angle regime this leads to a theory that is close to that of Bistritzer *et al.* [2], but differs in the choice of momentum scale. In the large angle this approach yields electronic versions of the Hamiltonians first derived on symmetry grounds by Mele [3]. We use these low energy approaches to give an overview of the $T = 0$ electronic properties of the twist bilayer system, with a particular focus on the localization of electrons, mixing of single layer graphene states by the interaction, and low energy density of states features.

[1] S. Shallcross, S. Sharma, and O. Pankratov, *Phys. Rev. B* **87**, 245403, 2012.
[2] R. Bistritzer and A. H. MacDonald. *Proc. Natl Acad. Sci.*, **108:12233**, 2010.
[3] E. J. Mele. *Journal of Physics D Applied Physics*, **45:154004**, 2012.

MA 54.5 Fri 10:30 POT 081

RKKY interaction in the AB stacked graphene bilayer: interstitial impurities and a diverging propagator. — •Nicolas Klier, Sam Shallcross, and Oleg Pankratov — Theoretische Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7B2, 91058 Erlangen

The interaction between spin polarised impurities in graphene displays a number of novel features that arise both from the valley degree of freedom that graphene possesses, as well as the linearly vanishing density of states at the Dirac point [1,2]. Multilayer graphene systems offer both the possibility of realistic interstitial (i.e., interlayer) impurities, as well as novel electronic features. In particular, the Bernal stacked (AB) bilayer exhibits low energy (chiral) bands as well as high energy bonding and anti-bonding bands. We demonstrate that at the bonding to anti-bonding *gap edge* there is an logarithmic divergence $\log(E - E_g)$ in the propagator on one sublattice, with E the energy and E_g the energy of the bonding to anti-bonding gap (0.38 eV). This leads to a number of dramatic consequences for the RKKY interaction, most notably: (i) a $R^{-5/2}$ impurity interaction at the gap edge, and, (ii) for interstitial impurities a discontinuous change in the Fermi surface spanning vector that drives the RKKY at the gap edge. We further derive the finite temperature behaviour of this system on the basis of finite temperature perturbation theory.

[1] M.Sherafati, and S.Satpathy, Phys. Rev. B 84, 125416, 2011.
[2] F.Parhizgar, and M.Sherafati, and R.Asgari, and S.Satpathy, Phys. Rev. B 87, 165429, 2013.

MA 54.6 Fri 10:45 POT 081

Conductivity of two-dimensional charge carriers with non-parabolic dispersion — Bretislav Sopik[1], Janik Kailasvuori[2,3], and •Maxim Trushin[4] — [1]Central European Institute of Technology, Masaryk University, Kamenice 735, 62500 Brno, Czech Republic — [2]International Institute of Physics, Universidade Federal do Rio Grande do Norte, 59078-400 Natal-RN, Brazil — [3]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany — [4]University of Konstanz, Fachbereich Physik, M703 D-78457 Konstanz

We investigate the conductivity of two-dimensional charge carriers with the non-parabolic dispersion k^N with N being an arbitrary natural number assuming the delta-shaped scattering potential as a major source of disorder. We employ the exact solution of the Lippmann-Schwinger equation to derive an analytical Boltzmann conductivity formula valid for an arbitrary scattering potential strength. We proceed further with a numerical study based on the finite size Kubo

formula which assesses the applicability range of our analytical model. We find that for any $N > 1$, the conductivity demonstrates a linear dependence on the carrier concentration in the limit of a strong scattering potential strength. This finding agrees with the conductivity measurements performed recently on chirally stacked multilayer graphene [1] where the lowest two bands are non-parabolic and the adsorbed hydrocarbons might act as strong short-range scatterers.

[1] L. Zhang, Y. Zhang, J. Camacho, M. Khodas I. Zaliznyak, Nature Physics **7**, 953-957 (2011).