O 82: [MA] Graphene (jointly with DY, DS, HL, O, TT)

Time: Thursday 15:15–17:00 Location: HSZ 401

O 82.1 Thu 15:15 HSZ 401

Tunable edge magnetism in graphene — •Manuel J. Schmidt[1], Daniel Loss[1], David J. Luitz[2], and Fakher F. Assaad[2] — [1]Universität Basel, Switzerland — [2]Universität Würzburg, Germany

Edge states with nearly zero energy that are exponentially localized at zigzag edges of graphene ribbons, in combination with electron-electron interactions give rise to edge magnetism. We show how the characteristic momentum-dependence of the transverse wave function of the edge states may be exploited in order to manipulate the edge state bandwidth [1]. This allows to tune graphene edges from the usual edge magnetism regime, over a regime of itinerant one-dimensional ferromagnetism, down to the non-magnetic Luttinger liquid regime. As an example we discuss graphene/graphane interfaces for which we propose an experimental setting in which the bandwidth may be tuned in situ by means of electrostatic gates [2]. We introduce an effective one-dimensional model for the edge states, on the basis of which we investigate the tunability of edge magnetism. Our analysis uses essentially three techniques: by a mean-field treatment of the effective interaction, the phase diagram is established. Quantum fluctuations, which may not be neglected in one dimension, are taken into account on the basis of a bosonization technique. Finally, these analytical calculations are complemented by an exact diagonalization analysis of the effective edge state model.

[1] M.J. Schmidt and D. Loss, Phys. Rev. B 81, 165439 (2010).
[2] M.J. Schmidt and D. Loss, Phys. Rev. B 82, 085422 (2010).

O 82.2 Thu 15:30 HSZ 401

Ballistic transport at room temperature in micrometer size multigraphene — •Srujana Dusari[1], José Luis Barzola Quiquia[1], Pablo Esquinazi[1], and Nicolas Garcia[2] — [1]Division of Superconductivity and Magnetism, Universität Leipzig, Faculty of Physics and Earth Sciences, Institute for Experimental Physics II, Linnéstr. 5, 04103 Leipzig, Germany — [2]Laboratorio de Física de Sistemas Pequeños y Nanotecnología, Consejo Superior de Investigaciones Científicas, Serrano 144, E-28006 Madrid, Spain

As an emergent material for electronic applications, graphite and graphene and their electrical transport properties have become a subject of intense focus. By performing transport measurements through micro and submicro constrictions in ~10 nm thick graphite samples, we observe drastic increase in the resistance decreasing the constriction width. Our experimental observations indicate that electrons behave ballistically even at room temperature and with mean free path of the order of microns. The values obtained for the mobility (~10^7 cm^2 v^-1 s^-1) and density of the electrons (~10^8 cm^-2) indicates that the graphene layers inside graphite are of higher quality than single ones. The decrease of magneto resistance with decreasing constriction width also indicates that the carrier mean free path is larger than few microns at room temperature.

O 82.3 Thu 15:45 HSZ 401

Long spin relaxation times in bilayer graphene — •Frank Volmer[1,2], Tsung-Yeh Yang[1,2], Jayakumar Balakrishnan[3], Ahmet Avsar[3], Manu Jaiswal[3], Julia Samm[1,2], Syed Rizwan Ali[1,2], Alexandre Felix Pachoud[3,4], Ming-Gang Zeng[3,5], Mihaita Popinciuc[1,2], Barbaros Özyilmaz[3,4,5], Gernot Güntherodt[1,2], and Bernd Beschoten[1,2] — [1]II. Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany — [2]JARA: Fundamentals of Future Information Technology, 52074 Aachen, Germany — [3]Department of Physics, National University of Singapore, 117542 Singapore — [4]NUS Graduate School for Integrative Sciences and Engineering (NGS), Centre for Life Sciences (CeLS), 117456 Singapore — [5]Nanocore, National University of Singapore, 117576 Singapore

The demonstration of micrometer long spin relaxation lengths in graphene at room temperature has made this material a promising candidate for spintronic applications. We investigated the spin transport in the non-local spin valve geometry in bilayer graphene using MgO barriers for spin injection. We demonstrate that the dominant spin relaxation mechanism in bilayer graphene is of the D'yakonov-Perel' type. In this case the spin dephasing time scales inversely with the charge carrier mobility. At room temperature spin dephasing times of up to 2 ns are measured in samples with the lowest mobility.

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O 82.4 Thu 16:00 HSZ 401

The graphene Landau quartet unveiled — •Sander Otte[1,2,3], Young Jae Song[2,3], and Joseph Stroscio[2] — [1]Delft University of Technology, The Netherlands — [2]National Institute of Standards and Technology (NIST), USA — [3]Maryland NanoCenter, University of Maryland, USA

Some of the unique properties of graphene come to expression when its electrons are locked into Landau levels in an external magnetic field. Due to spin-degeneracy in combination with the two-atom unit cell of the hexagonal lattice (valley degeneracy), each Landau level is expected to host four electrons. We use a newly completed dilution refrigerator cooled STM system to study epitaxial graphene at 10 mK in magnetic fields up to 15 T. The unparalleled energy resolution of this instrument enables us to break the predicted fourfold Landau level degeneracy and to measure the sublevel splittings as a function of the magnetic field. Surprisingly large splittings are found for the valley states, which are not magnetic by nature. In addition, intriguing partial filling of the sublevels is observed, yielding access to promising electron correlation effects.

O 82.5 Thu 16:15 HSZ 401

Emergent magnetism of *5d* transition-metal adatoms on Graphene — •Hongbin Zhang[1], Cesar Lazo[2], Stefan Blügel[1], Stefan Heinze[2], and Yuriy Mokrousov[1] — [1]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Institute of Theoretical Physics and Astrophysics, University of Kiel, 24098 Kiel, Germany

Owing to its peculiar electronic structure, graphene serves as a playground for many interesting physical properties and has drawn a lot of attention recently [1]. In this work, using the first principles FLAPW methods, we investigate the magnetism of 5*d* transition metal (TM) atoms from Hf to Pt deposited on graphene in different supercell geometries. By taking into account the effect of atomic relaxations, we find that most of the 5*d* TMs exhibit strong local magnetism when deposited on graphene. A combination of large spin moments with strong spin-orbit coupling in considered adatoms leads to gigantic values of the magnetic anisotropy energies, reaching values as large as 30 meV/atom. We also investigate the influence of external electric fields on the magnetic properties of 5*d* TM adatoms and discuss possible transport applications. We acknowledge funding under HGF-YIG Programme VH-NG-513.

[1] A. H. C. Neto, *et al.*, Rev. Mod. Phys. **81**, 109 (2009).

O 82.6 Thu 16:30 HSZ 401

Anisotropic magnetoresistance observed in graphite flakes — •Jose Barzola-Quiquia, Andreas Schadewitz, Winfried Böhlmann, and Pablo Esquinazi — Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig, Germany

The possibility to have magnetic order at room temperature in a system without 3d metallic magnetic elements attracts the interest of the solid state physics community. Experimental evidence for the existence of ferromagnetism in virgin and proton-irradiated graphite samples was published based on SQUID [1] and XMCD [2] measurements. An alternative method to detect magnetic order is to measure the magnetoresistance (MR). The MR develops a characteristic butterfly loop when measured vs. magnetic field. In this work we have studied the magnetotransport properties of micrometer-size and ~10 nm thick graphite flakes as a function of temperature, magnetic field applied in- and out-plane configurations. We investigated especially the MR as a function of the angle between current and applied field in order to study the anisotropic magnetoresistance (AMR). Virgin graphite flakes show a small AMR and flakes treated with H_2SO_4 show an increase in the AMR signal. The observed behavior provides evidence for intrinsic and induced ferromagnetism at the surface of graphite samples. This investigation also was complemented using SQUID magnetometry on graphite powder in virgin state and after treatment with H_2SO_4 resulting in a clear ferromagnetic signal. [1] P. Esquinazi et al., Phys. Rev. B 66, 024429 (2002), Phys. Rev Lett. 91, 227201 (2003). [2] H. Ohldag et al., Phys. Rev. Lett. 98, 187204 (2007).

O 82.7 Thu 16:45 HSZ 401

Magnetic clusters on graphene flakes — •Wolfgang Landgraf,

Sam Shallcross, and Oleg Pankratov — Lehrstuhl fur Theoretische Festkorperphysik, Staudstr. 7-B2, 91058 Erlangen, Germany.

We present an investigation of the properties of magnetic ad-atoms and clusters on graphene flakes. We consider clusters of 1-7 atoms of metals from the 3d series assembled on graphene flakes composed of the order of 100 carbon atoms. All calculations are performed within the spin density functional theory formalism in the local density approximation. We elucidate the range of the magnetic interaction for pairs of magnetic ad-atoms on graphene flakes, as well as the equilibrium magnetic structure for various cluster types. By a comparison of such clusters on flakes with their counterparts on extended sheets, we are able to elucidate the role of the flake shape upon the magnetic interaction. In this way we determine the role of confinement on the magnetic interaction, and comment on the possibility of using flake shape as a design parameter of magnetic nanostructures on graphene flakes.