SYSG 1: Spin Properties of Graphene

Time: Tuesday 9:30–12:15 Location: HSZ 02

Invited Talk SYSG 1.1 Tue 9:30 HSZ 02
Intrinsic magnetism in graphene — •Irina Grigorieva — School of Physics and Astronomy, University of Manchester, UK

I will review our recent experiments on inducing and controlling magnetic response in graphene via introduction of point defects such as vacancies and adatoms. Graphene is hailed as potentially an ideal material for spintronics due to its weak spin-orbit interaction and the ability to control its electronic properties by the electric field effect. We have demonstrated that point defects in graphene - both vacancies and adatoms - carry magnetic moments, leading to pronounced paramagnetic behaviour that dominates graphene's low-temperature magnetism. Even better, we show that the defect magnetism is itinerant (i.e. due to localisation of conduction electrons) and can be controlled by doping, so that the induced magnetic moments can be switched on and off. This not only adds important functionality to potential graphene devices but also has important implications for spin transport.

Invited Talk SYSG 1.2 Tue 10:00 HSZ 02
Defect Induced Magnetic Moments in Graphene — •Roland Kawakami — The Ohio State University, Columbus, OH, USA — University of California, Riverside, CA, USA

We utilize non-local spin transport measurements to detect the presence of defect induced magnetic moments in graphene. As shown in this talk, point defects such as hydrogen adatoms and lattice vacancies generate magnetic moments in graphene that have substantial exchange coupling with the conduction electrons. Therefore, this exchange coupling produces spin relaxation in the conduction electrons. Specifically, a characteristic field dependence of the non-local spin transport signal identifies the presence of the magnetic moments. Furthermore, Hanle spin precession measurements indicate the presence of an exchange field generated by the magnetic moments. The entire experiment including spin transport is performed in an ultra-high vacuum chamber, and the characteristic signatures of magnetic moment formation appear only after hydrogen adatoms or lattice vacancies are introduced.

Invited Talk SYSG 1.3 Tue 10:30 HSZ 02
Role of MgO barriers for spin and charge transport in Co/MgO/graphene spin-valve devices — •Bernd Beschoten — 2nd Institute of Physics and JARA-FIT, RWTH Aachen University, 52074 Aachen, Germany

We investigate the influence of MgO barriers on spin and charge transport in single (SLG) and bilayer (BLG) graphene spin-valve devices. Similar to previous studies on BLG [1], we observe a $1/\mu$ of the spin lifetime in SLG devices. This general trend is only observed in devices with large contact resistance area products $R_cA > 1\text{k}\Omega\mu\text{m}^2$. In devices with long spin lifetimes, we furthermore observe a second Dirac peak, which results from charge transport underneath the contacts. In contrast, all devices with $R_cA < 1\text{k}\Omega\mu\text{m}^2$ only exhibit a single Dirac peak. Additionally, the spin lifetime is significantly reduced indicating that an additional spin dephasing occurs underneath the electrodes. In the latter devices we achieve a gradual increase of R_cA values by successive oxygen treatments. With this manipulation of the contacts both spin lifetime and amplitude of the spin signal can significantly be increased by a factor of seven in the same device. Finally, we present a new method to fabricate graphene-based lateral spin valves on hexagonal boron nitride yielding spin lifetimes above 3 ns, spin diffusion length above 10 μm and large charge carrier mobilities above 30.000 cm^2/Vs.

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[1] T.-Y. Yang *et al.*, Phys. Rev. Lett. 107, 047206 (2011).
[2] F. Volmer *et al.* Phys. Rev. B 88, 161405(R)(2013).

Coffee break (15 min.)

Invited Talk SYSG 1.4 Tue 11:15 HSZ 02
Defect-Mediated Spin Relaxation and Dephasing in Graphene — Mark Lundeberg[1,2], Silvia Folk[1], and •Joshua Folk[1] — [1]University of British Columbia, Vancouver, Canada — [2]Institute of Photonic Sciences, Barcelona, Spain

This talk will describe a series of transport measurements that disentangle mechanisms of spin and orbital phase relaxation in graphene. The measurements are based on well-known quantum interference phenomena–weak localization and universal conductance fluctuations. We show that a careful analysis of the in-plane magnetic field and temperature dependences of these effects can separately quantify spin-orbit and magnetic scattering rates; this technique works especially well in graphene due to its single-atom thickness. Spin relaxation in exfoliated graphene on SiO_2 is found to be dominated by magnetic scattering (scattering off of magnetic defects), with a smaller contribution from spin-orbit interaction. A similar measurement performed in graphene on SiC suggests that both magnetic scattering and spin-orbit interaction are a factor of 10 stronger than in exfoliated graphene.

Invited Talk SYSG 1.5 Tue 11:45 HSZ 02
Electron spin relaxation in graphene: resonant scattering off local magnetic moments — •Jaroslav Fabian, Denis Kochan, and Martin Gmitra — Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

Dirac electrons in graphene should have large spin relaxation time, some microseconds, due to the weak spin-orbit coupling of its itinerant electrons. Yet experiments show spin lifetimes as short as 100 ps. Traditional spin relaxation mechanisms, Elliott-Yafet and Dyakonov-Perel, seem incapable to explain such short lifetimes, even though some external influences such as hydrogen adatoms seem to induce giant local spin-orbit coupling [1] and so enhance spin-orbit induced spin flips. We believe that the culprit may instead be local paramagnetic moments due to vacancies and some adatoms. As the local moments sit on resonance sites, the spin flip is resonantly enhanced. These resonant local moments are acting as spatial spin hot spots: they may contribute little to momentum relaxation of graphene, but dominate the spin relaxation. This new mechanism explains the observed 100 ps spin lifetimes with as little as 1 ppm of local moments [2]. We acknowledge support from DFG SFB 689, SPP 1285, GRK 1579, and EC under Graphene Flagship (Contract No. CNECT-ICT-604391). [1] M. Gmitra, D. Kochan, and J. Fabian, Spin-orbit coupling in hydrogenated graphene, Phys. Rev. Lett. 110, 246602 (2013);[2] D. Kochan, M. Gmitra, and J. Fabian, Spin relaxation mechanism in graphene: resonant scattering by magnetic impurities, arXiv:1306.0230.