Spintronics in graphene based proximity Van der Waals heterostructures

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Abstract

I will introduce spintronics in graphene, highlighting the elementary experimental techniques, using ferromagnetic electrodes for spin injection and spin detection, and applied magnetic fields to control the spin direction by Hanle spin precession. This has shown graphene as an ideal long range carrier of electronic spins [1]. I will give examples how (strongly anisotropic) spin relaxation can be induced in graphene using proximity to semiconducting transition metal dichalcogenides (TMDs) with strong spin orbit interaction [2]. In similar graphene/TMD systems it was shown that interconversion of spin and charge currents can be achieved, using proximity induced spin Hall and Rashba-Edelstein mechanisms and their reciprocals [3].
As the main subject I will discuss how graphene can be made magnetic by the proximity of the layered Van der Waals antiferromagnet CrSBr. We showed that a strong exchange field of 170T, corresponding to a spin splitting of about 10 meV is induced in the graphene, and modifies the electronic bandstructure [4]. Non-local and local charge and spin transport measurements have shown that in this system a spin polarization of the conductivity of 14 % is obtained, similar in value to that in conventional 3D metallic ferromagnets. In addition the proximity induced spin polarization has resulted in a spin dependent Seebeck effect, where a thermal gradient induces a pure spin current due to the spin dependent values for the Seebeck coefficients [4].
I will discuss ongoing experiments where we aim at controlling the magnitude, as well as sign, of the spin polarization in the magnetic graphene by gate tuning the carrier density and Fermi energy. This will also allow to make new device functionalities such as lateral spin valve devices based on magnetic graphene, and fully spin polarized edge channels in high magnetic fields. Finally I will discuss how we intend to use these systems to make a fully spin polarized 2D system, a two dimensional spin gas.

References

[1] W. Han, R.K. Kawakami, M. Gmitra and J. Fabian, Nat. Nanotechn. 9, 794 (2014).
[2] T. Ghiasi, J. Ingla Aynes, A.A. Kaverzin, and B.J. van Wees, Nano Lett. 17.12, 7528 (2017).
[3] T.S. Ghiasi , A.A. Kaverzin, P.J. Blah, and B.J. van Wees, Nano Lett. 19.9, 5959 (2019).
[4]. T.S. Ghiasi, A.A. kaverzin, A.H. Dismukes, D.K. de Wal, X. Roy, B.J. van Wees, Nature Nanotechn. 16, 788 (2021).