Spin-orbit proximity phenomena in graphene

Sergio O. Valenzuela[1,2]
Contributing authors: L. A. Benítez,[2,3] Z. M. Gebeyehu,[2,3] A. Arrighi,[2,3] W. Savero Torres,[2] M. Timmermans,[2] J. F. Sierra,[2] J. H. García,[2] M. V. Costache,[2] S. Roche[1,2]

[1] *Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Spain*
[2] *Catalan Institute of Nanoscience and Nanotechnology ICN2, CSIC and the Barcelona Institute of Science and Technology (BIST), Bellaterra, 08193 Barcelona, Spain*
[3] *Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain*

SOV@icrea.cat

Two-dimensional atomic crystals offer a unique platform to design new materials, in which proximity effects are maximized and can help tailor their electrical, optical and spin properties. Amongst these materials, graphene has emerged as a centrepiece for future spintronics, owing to its tuneable electronic properties and ability to transport spin information over very long distances [1]. For active devices, however, spin manipulation remains an open challenge. Such a challenge can be resolved with spin-orbit coupling (SOC) induced by proximity effects. Here, I will present recent results regarding spin dynamics in graphene-based van der Waals heterostructures. In the first part, I will review the microscopic mechanisms that influence the spin propagation in pristine graphene, including the presence of hot carriers [2]. In the second part, I will discuss our recent experiments on proximity-induced SOC and spin-to-charge conversion in stacks of graphene and transition metal dichalcogenides (TMDC) and in graphene in contact with metals such as Pt [3,4]. I will show that key information can be obtained from the spin-lifetime anisotropy, as it is determined by the preferential direction of the spin-orbit fields that cause the spin relaxation. Even though the spin-lifetime in graphene on SiO_x is isotropic, it becomes strongly anisotropic in bilayers comprising graphene and a TMDC (Fig. 1). Indeed, it varies over one order of magnitude depending on the spin orientation and is largest for spins point out of the graphene plane, even at room temperature [3]. This suggests that the strong spin-valley coupling in the TMDC is imprinted in graphene and felt by propagating spins [4,5], a phenomenon that can also lead to an enhanced spin-to-charge conversion efficiency.

References

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Figures

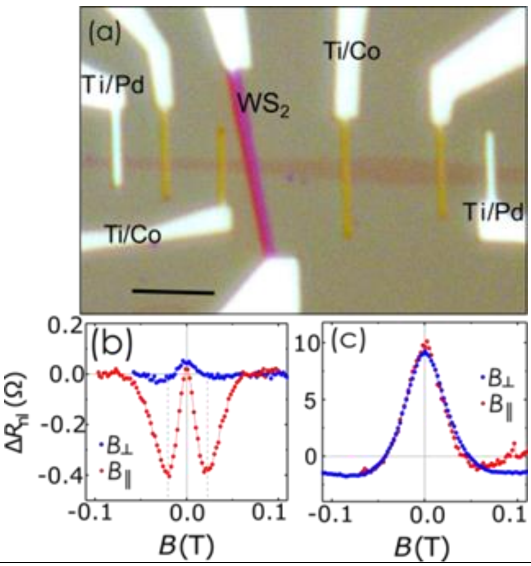

Figure 1: Spin relaxation anisotropy in graphene-tungsten disulphide. (a) Device. (b) Spin precession with out-of-plane and in-plane magnetic field. (c) ibid, in a reference device [3].