Room-temperature charge to spin interconversion in proximitized graphene

Sergio O. Valenzuela[1,2]
L. A. Benitez, L. Camosi, J. F. Sierra, J. Světlík, W. Savero Torres, M. V. Costache, I. Fernández Aguirre, M. Timmermans, J. H. García, S. Roche.
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
SOV@icrea.cat

The atomically thin nature of 2D materials promotes the design of van der Waals heterostructures by proximity effects originating from short-range interactions [1]. This designer approach is particularly compelling for spintronic devices, which harness their functionalities from thin layers of magnetic and non-magnetic materials and the interfaces between them [1,2]. On the other hand, the ability to control the generation of spins in arbitrary directions is a long-sought goal in spintronics. Charge to spin interconversion (CSI) phenomena strongly depend on symmetry. Systems with reduced crystal symmetry could allow anisotropic CSI with unconventional components, where charge and spin currents and the spin polarization are not mutually perpendicular to each other. In this talk, I will first demonstrate that proximity of a high-symmetry semiconducting transition metal dichalcogenide such as WS_2 enhances the CSI in graphene [3]. I will further show that the CSI is tunable with electrostatic gating and that the generated spin current and spin density by the spin Hall and the inverse spin galvanic effects, respectively, are mutually perpendicular to each other. Finally, I will show experimental results demonstrating that the CSI in graphene in contact with low-symmetry WTe_2 induces spins with components in all three spatial directions [4]. By performing multi-terminal nonlocal spin precession experiments, with specific magnetic fields orientations, I discuss how to disentangle the CSI from the spin Hall and inverse spin galvanic effects in this situation (Figure).

References

[1] J. F. Sierra et al., Nature Nano. 16 (2021) 856–868
[2] H. Yang, S O. Valenzuela et al., Nature 606 (2022) 663
[3] L. A. Benítez et al., Nature Mater. 19 (2020) 170
[4] L. Camosi et al., 2D Mater. 9 (2022) 035014

Figure

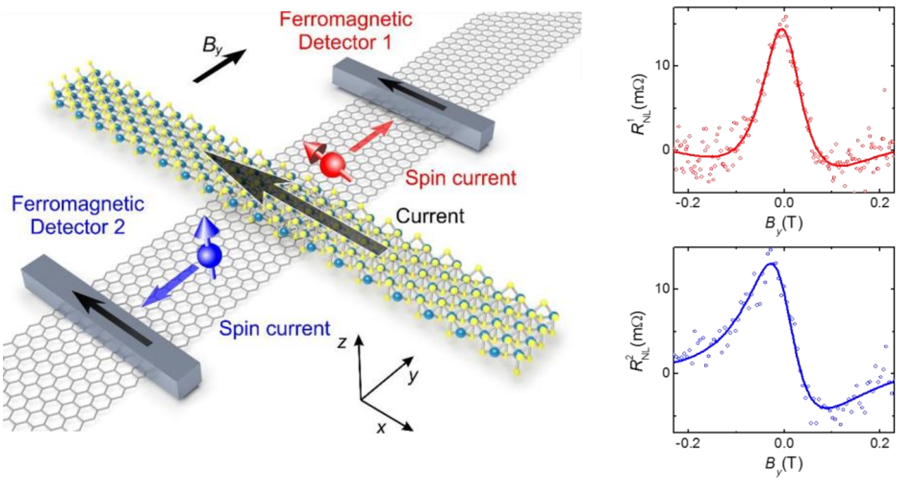

Figure: Left: detection scheme of the CSI in low symmetry structures, resulting in distinct spin accumulation on the left (blue) and right (red) ferromagnetic electrodes. Right: signals associated to such spin accumulation