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Charge-spin conversion in atomically-thin van der Waals heterostructures

Abstract

In the past decade, graphene has emerged as a strong contender for next-generation spintronic devices due to its long spin diffusion lengths and gate tunable spin transport at room temperature [1]. However, the lack of a band gap and its weak spin–orbit coupling (SOC) pose major limitations for injection and control of spin currents. The recent capability to assemble layered crystals into vertical heterostructures offers a realistic prospect of overcoming graphene's weaknesses [2]. When graphene is paired with group-VI (semiconducting) dichalcogenide monolayers [MX_2 (M = Mo, W; X = S, Se)], its band structure develops rich spin-orbital textures via proximity effect [3], providing a clear and exciting path towards realising all-spin logic devices from ultra-thin and gate-tuneable van der Waals (vdW) heterostructures.

In this talk, I will present an overview of our latest results on graphene with interface-induced SOC [4-5]. I will show that graphene-MX_2 heterostructures generally support current-driven spin polarization; a relativistic transport phenomenon known as the inverse spin galvanic effect (ISGE). Owing to the characteristic spin winding of interfacial states in graphene on a MX_2 monolayer, the predicted ISGE possesses striking similarities to charge-to-spin conversion generated by ideal topologically protected surfaces. The ISGE conversion efficiency is found to be little sensitive to impurity scattering, with the proper figure of merit attaining values as great as 30% at room temperature [4]. The giant charge-to-spin conversion in a graphene system with proximity spin-orbital effects promises unique advantages for low-power applications, including the tuning of spin polarization by a gate voltage (see Figure). The implications of our general microscopic theory of charge-spin dynamics to 2D Dirac interfaces of current experimental relevance will be briefly discussed [5].

Figures

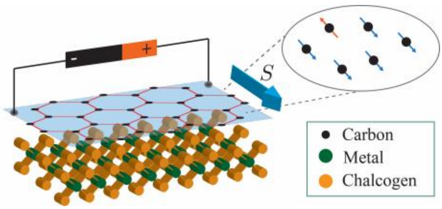

Figure 1. Graphene is placed on top of an ultra-thin semiconducting base with two types of atoms forming an atomically-thin "sandwich". The proximity to the semiconducting layer re-orients the spin of conduction electrons in graphene, allowing all-electrical generation of 'spin signals' (i.e., a net spin polarization) by application of a small gate voltage. (Credit: A. Ferreira)

References

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