Recent advances in van der Waals heterostructure-based Spintronics

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I will discuss how physical properties of graphene can be strongly enriched and manipulated by harvesting the large amount of possibilities of proximity effects with magnetic insulators, strong spin-orbit coupling SOC materials such as transition metal dichalcogenides (TMD) and topological insulators (TI). First I will introduce some foundations of spin transport for Dirac fermions propagating in supported graphene devices or interfaced with strong SOC materials, with a particular emphasis on how spin dynamics is monitored by the nature of SOC induced in graphene by nearby TMDs and TIs. Such proximity effect will be revealed by giant spin lifetime anisotropy, with spins oriented in the graphene plane relaxing much faster than spins pointing out of the plane. This anisotropy, arising from the specific nature of the SOC induced in the graphene layer and crucially on the symmetry of the graphene/TMD & TI interfaces, also inspires ways for manipulating spin properties using proximity effects, such as inducing and tailoring Spin Hall effect by proximity effects. Finally, I will present some spin transport results in quasiballistic graphene devices, as well as some universal features in polycrystalline graphene, all results reinforcing the promising future of graphene and other 2D materials in improving mainstream spin-based memories or advancing spin logics technologies.