Opportunities for spintronics with novel 2d materials

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Two dimensional materials, such as graphene, transition metal dichalcogenides, or phosphorene, offer immense opportunities for spintronics [1]. Being ultimately thin, these materials could make the thinnest diodes and transistors. Being essentially a surface, they are also susceptible to adatoms and admolecules which can induce giant spin-orbit coupling [2]. This is a great opportunity, allowing us to decorate (functionalize) graphene and like materials with specific defects to make desired properties. However, adatoms can also induce local magnetic moments that can lead to ultrafast spin relaxation, seen in experiments. In fact, we have introduced a novel spin relaxation mechanism, based on this fact, as well as on the theoretical predictions that adatoms and admolecules generating magnetic moments can also act as resonant scatterers. This mechanism successfully explains the experimental findings for both monolayer [3] and bilayer [4] graphene. I will also talk about heterostructures of graphene and two-dimensional transition-metal dichalcogenides (TMDCs) which we proposed to facilitate optical spin injection into graphene [5], since TMDCs are direct-gap semiconductors and one can generate in them spin and valley polarized carriers by illumination with circularly-polarized light. In addition, TMDCs induce a giant proximity spin-orbit coupling in graphene [5, 6]. The extreme case is graphene on WSe_2 which we predicted [6] to exhibit a band inversion and topological helical edge modes in zig-zag nanoribbon geometries. This makes real the prospect of investigating topological states in graphene-based devices, overcoming the weakness of the intrinsic graphene's spin-orbit coupling.

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