iSpinText: Induced Spin Textures in van der Waals Heterostructures

Main area: Advanced nanofabrication and spintronics
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Abstract

After the discovery of graphene it was soon realized, that graphene is the perfect candidate for spintronics, due to its high mobility, low spin-orbit coupling and small or absent hyperfine fields. By now, spin relaxation lengths longer than 10 µm have been demonstrated. Although the results are still far from expectations, the achieved values already make graphene an ideal platform to transfer spin information. The key question at the present stage, how the manipulation of spin can be achieved with graphene devices. In this proposal we will investigate novel routes to add electric and magnetic control over the spin by introducing different spin textures in graphene. Spin textures are induced by developing various 2D proximity heterostructures:

First, using magnetic insulators exchange interaction will be induced in graphene and in topological insulators. This will be confirmed by anomalous Hall measurements. Moreover, the magnetic insulator substrates will also allow magnetic gating of the spin-current.

Second, spin-orbit interaction (SOI) will be induced in graphene by the proximity of other 2D materials. These materials include topological insulators, transition metal dichalcogenids, and novel 2D materials, with huge spin-orbit coupling, like BiTeI. The induced SOI can enable electrical control of the spin-direction. The presence of SOI will be tested by weak localization, and spin-Hall measurements.

It is also predicted, that if the proper SO terms are present in graphene, it can acquire topological properties and turn into the quantum spin-Hall phase. Moreover, new 2D materials, like BiTeI will be interesting for the field of Spintronics by themselves and these materials will also give new building blocks for producing Van der Waals heterostructures.

Finally, we will introduce real-space textures into graphene by using metallic superstructures. For this, ferromagnetic and superconducting structures will be fabricated on top of graphene, separated by few layers of h-BN. Here, the stray field of the nanomagnets will be used to induce topologically interesting structures, such as skyrmions. The superconducting electrodes on top of graphene will suppress the magnetic fields due to Meissner effect, and the tailoring of local magnetic fields will be possible. These local fields will be used for spintronics and electron-optical experiments.

To achieve our goals we will produce proximity structures based on Van der Waals pick-up technique, and will develop advanced fabrication methods, like point-contacts to encapsulated graphene, or metallic superstructures separated from graphene by few layers of h-BN. The experiments will be supported by DFT and transport calculations.

The methods and goals outlined in this proposal will bring graphene based future spintronics applications closer.

Consortium

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