Spin Hall, Edelstein and Magnetic effects in 2D Materials Heterostructures

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Engineering two-dimensional (2D) materials heterostructures by combining the best of different materials in one ultimate unit can offer a plethora of opportunities in condensed matter physics. Here, we combine different 2D materials to create proximity induced spin-orbit coupling (SOC), novel spin-textures and magnetism in graphene, and to detect the spin Hall and Edelstein effects in topological materials.

Among the 2D materials, while CVD graphene is shown to be an excellent medium for long distance spin communication [1], the insulating CVD h-BN has shown a very large tunnel spin polarization up to 65% at room temperature [2]. Furthermore, by inducing SOC and spin absorption effects, we demonstrated an electrical gate control of spin-polarization and spin lifetime in graphene/MoS_2 heterostructures at room temperature [3].

Furthermore, the recent discovery of 2D magnets and topological materials has opened the opportunities to induce magnetism, novel spin textures and to create spin polarized sources using all 2D materials heterostructures. Using van der Waals heterostructures of magnetic insulator and graphene we demonstrate proximity induced magnetic-exchange interaction causing significant modification of spin precession in graphene with an anisotropic spin texture [4].

The topological insulators (TIs) are known to have a spin polarized surface states generated by strong SOC induced band inversion. We combined graphene with TIs in van der Waals heterostructures to demonstrate the emergence of a strong and tunable proximity-induced SOC in graphene, nearly an order of magnitude higher than in pristine graphene [5].

Recently, using layered Weyl semimetals, we observed a giant spin Hall and Edelstein effect at room temperature [6]. We demonstrate the creation and detection of the pure spin current generated by spin Hall phenomenon by making van der Waals heterostructures with graphene (Figure 1).

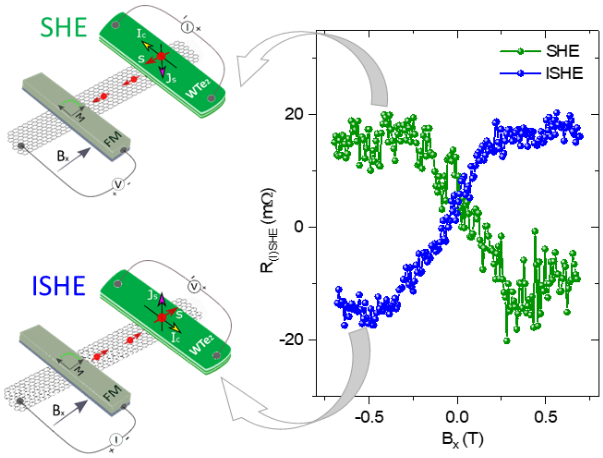

Figure 1: Observation of spin Hall effect (SHE) and inverse spin Hall effect (ISHE) in WTe_2 by using heterostructures with graphene [6].

References

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