Proximity spin-orbit physics of graphene on transition-metal dichalcogenides

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ABSTRACT

Graphene spintronics has achieved a level at which progress appears rather gradual. One difficulty stems with the spin injection itself. While in other materials, metals and conventional semiconductors, there are at least two complementary techniques with which electron spins are injected, controlled, and detected (optical spin orientation, electron spin resonance, electrical spin injection), graphene has been investigated with electrical spin injection mostly.

To enable new technologies based on electron spins in two-dimensional materials, in this lecture we will be searching for new physical principles allowing for additional spin controls. We will be discussing pioneering approach based on graphene on two-dimensional transition metal dichalcogenides (TMDC) as a platform for optospintronics [1]. Optical spin injection in graphene is achieved by shining circularly polarized light onto the hybrid, exciting spin-polarized electrons in TMDC. Electrons are then transferred into graphene, where they diffuse and can be detected again optically or electrically, which is the usual way for graphene.

By scanning the whole family of dichalcogenides we will learn that graphene on WSe_2 exhibits an inverted Dirac band structure due to proximity enhanced spin-orbit coupling in graphene that originates from metal atom of TMDC. Further investigation of graphene nanoribbons on WSe_2 provides finding that they exhibit helical states inside the bulk gap, demonstrating the presence of the quantum spin Hall effect in these systems [2].

References

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