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Twist-angle dependence of the proximity spin-orbit coupling in graphene on transition-metal dichalcogenides

The physical properties of 2D material are generally sensitive to the interference with other materials placed in contact. it was shown that the negligibly small spin-orbit coupling (SOC) of intrinsic graphene can be significantly enhanced by superimposing on the surface of transition-metal dichalcogenides (TMDC), [1–4] and it is expected to be useful to realize spintronic manipulation in graphene. However, the importance of the relative lattice orientation has often been overlooked. The previous theoretical calculations of proximity spin-orbit effects of graphene/TMDC system are limited to commensurate geometry such as no-rotated one [2–4]. On the other hand, the sensitive dependence on the relative twist angle θ was noticed in various 2D heterostructures, and controlling θ is expected to be powerful means of manipulating their electronic properties.

Here we theoretically study the proximity spin-orbit coupling in graphene on transition-metal dichalcogenides monolayer stacked with arbitrary twist angles.[5] We find that the relative rotation greatly enhances the spin splitting of graphene, typically by a few to ten times compared to the non-rotated geometry, and the maximum splitting is achieved around 20°. The induced SOC can be changed from the Zeeman-type to the Rashba-type by rotation. The spin-splitting is also quite sensitive to the gate-induced potential, and it sharply rises when the graphene's Dirac point is shifted toward the TMDC band. The theoretical method does not need the exact lattice matching and it is applicable to any incommensurate bilayer systems. It is useful for the twist-angle engineering of a variety of van der Waals proximity effects.

References

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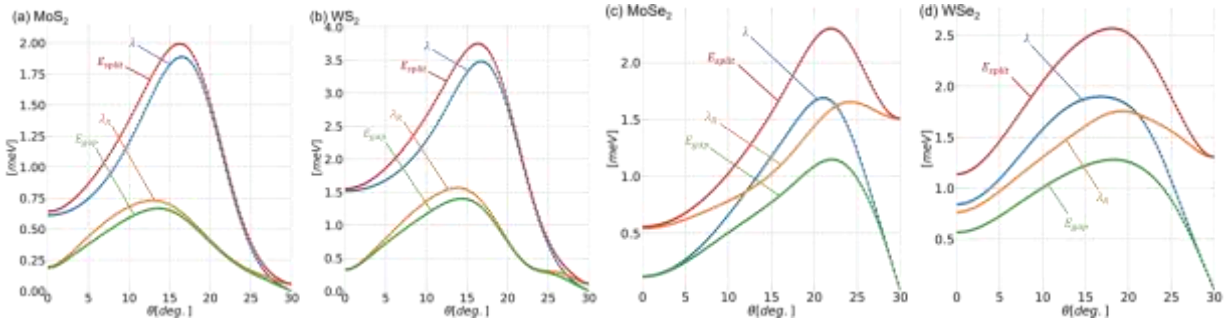

Figure 1: Spin-orbit splitting E_{split}, as a function of the twist angle θ in graphene-TMDC bilayers.