Spintronics with twisted structures

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2D materials are an exciting new material family in which the proximity effect is especially important and opens ways to transfer useful spintronic properties from one 2D material into another. For instance, transition metal dichalcogenides (TMD) can be used to enhance the spin-orbit coupling of graphene. The spin-orbit proximity in such graphene/TMD van der Waals heterostructures leads to spin-charge interconversion of out-of-plane spins due to spin Hall effect, first observed experimentally by using MoS_2 as the TMD [1], of in-plane spins perpendicular to the charge current due to the Rashba-Edelstein effect (REE), first observed by using WS_2 as the TMD [2,3], or to coherent spin precession with electrical control by using WSe_2 as the TMD [4].
Recent theoretical works have predicted the modulation of spin texture in graphene-based heterostructures by twist angle [5,6], although an experimental verification is missing.
We demonstrate the tunability of the spin texture and associated REE with twist angle in WSe_2/graphene heterostructures by spin precession experiments [7]. For specific twist angles, we experimentally detect a spin component radial with the electron's momentum (an "unconventional" REE [8]), in addition to the standard orthogonal component (conventional REE) and show that the helicity of the spin texture can be reversed by angle twisting, paving the way for the development of novel spin-twistronic devices.

References

[1] C.K. Safeer et al., Nano Lett. 19 (2019)1074
[2] T.S. Ghiasi et al., Nano Lett. 19 (2019) 5959
[3] L.A. Benitez et al., Nat. Mater. 19 (2020) 170 (2020)
[4] J. Ingla-Aynés et al., Phys. Rev. Lett. 127 (2021) 047202
[5] S. Lee et al., Phys. Rev. B 106 (2022) 165420
[6] K. Zollner et al., Phys. Rev. B 108 (2023) 235166
[7] H. Yang et al., Nat. Mater. 23 (2024) 1502
[8] F. Calavalle et al., Nat. Mater. 21 (2022) 526