Tunable spin-orbit interaction in graphene quantum devices

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In bilayer graphene a gap can be opened by applying a perpendicular electric field. Using suitably patterned gate electrodes one can define tunable potential landscapes, such as quantum point contacts and quantum dots. Spin-orbit interactions are weak in graphene because carbon is a light element. If bilayer graphene is placed next to a transition-metal dichalcogenide, such as WSe2, spin-orbit interactions can be induced by wave function overlap. We show how the strength of Rashba and Ising spin-orbit interactions can be quantified in 2D samples. In quantum point contacts, the lifting of the 4-fold degeneracy (spin and valley) by spin-orbit interactions leads to a modified level spectrum, a peculiar clustering of quantum Hall states (1+3 or 1+2+1 rather than 4-fold degeneracy) and a pronounced non-monotonic magnetic field dependence of energy levels because of exchange effects. In quantum dots the strength of spin-orbit interactions leading to a modified energy spectrum can be tuned by gate voltages.

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