

Chirality of the twisted graphene bilayer

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The electronic properties of two-dimensional graphitic devices are strongly influenced by the number of graphene layers. Whereas the monolayer band structure is linear at low-energy, the bilayer has a quadratic dispersion. Each system is also associated with a Berry phase of either π (monolayer) or 2π (bilayer) around the degeneracy point of the structure [1].

Graphene bilayer with a twist [2], one layer being slightly misoriented relative to the other, is a new system, which can interpolate between the two situations. For large rotations (misorientations) the two layers are decoupled and the band structure replicates that of the monolayer. On the other hand, for small rotations relative to Bernal stacking, one should recover the bilayer structure. Indeed, band deformations, involving the Dirac cones of each layer, have been observed experimentally [3,4].

We have developed a simple theoretical model [5] based on a previous continuum analysis [2,6], which describes the motion of the cones of different layer, depending on the twist angle. These two cones are separated for a non-zero rotation due to the rotation of the Brillouin zone of the upper layer relative to the lower one and eventually merge to create a quadratic dispersion in case of perfectly AB-stacked bilayer.

This merging is accompanied with peculiar topological properties, since it is derived via symmetry arguments of our Hamiltonian that the two cones each carry the same Berry phase, around the two Dirac points, for a given energy level. This has to be contrasted with previous study of merging of Dirac cones where the Berry phases are opposite [7]. This topological scenario can be tested through the quantum Hall effect where a robust zero-energy Landau level is predicted, which cannot be lifted by relatively strong magnetic field.

References

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