Twisted bilayer graphene in magnetic fields

Alessandro Cresti
Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, IMEP-LAHC, 38000 Grenoble, France
alessandro.cresti@grenoble-inp.fr

The band structure of graphene bilayers strictly depends on the twisting angle between layers. Bernal stacking (AB) generates parabolic semimetallic bands, while AA stacking keeps the Dirac linear dispersion and removes degeneracy. At very small so-called "magic angles", the large size of AA stacked regions explains the appearance of almost flat bands, which correspond to states localized in the AA regions as reported in [1].
Here, based on the same tight-binding model and with the inclusion of an orthogonal magnetic field [2], we observe the formation of dispersive Landau levels, which can be localized (in the AA or AB regions, for example) or extended depending on their velocity. These states are expected to be experimentally visible by scanning tunnelling microscopy and to determine the magnetotransport properties.
In-plane magnetic fields still affect the band structure due to the layer-dependent induced Dirac point shift. In an AA bilayer, where the Dirac points perfectly coincide, such an effect opens a small energy gap. These results smooth the path toward further investigations beyond the continuum model [3].

References

[1] G. Trambly de Laissardière et al., Phys. Rev. B, 86 (2012) 125413
[2] A. Cresti, Phys. Rev. B, 103 (2021) 045402
[3] Yves H. Kwanet al., Phys. Rev. B, 101 (2020) 205116

Figures

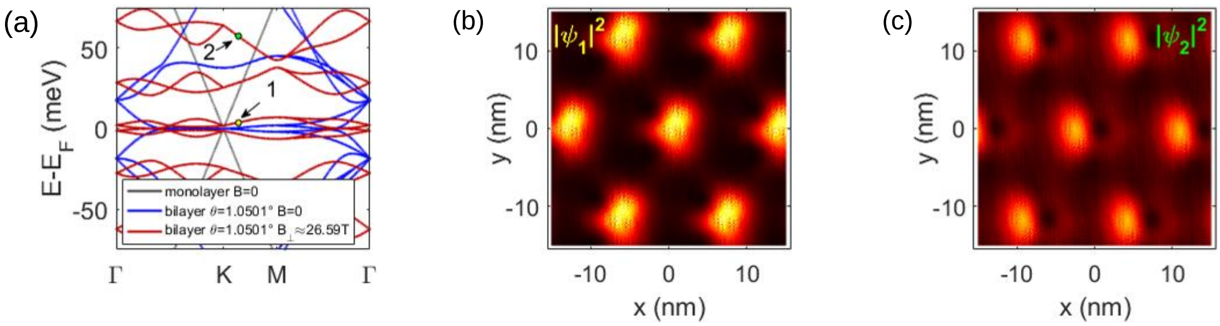

Figure 1: (a) Energy bands of monolayer and twisted graphene bilayer with a magic angle θ=1.0501° for orthogonal magnetic fields B=0 and B≈26.59 T. The almost flat low-energy bands for B=0 are typical of magic angles and confined in the AA regions [1]. (b) Squared eigenfunction at point 1 for B≈26.59 T. This state is mainly localized (lighter colour) in AA regions. (c) Same as (b) at the higher energy point 2. This state is more delocalized (with lower density, dark colour, in the AA regions).

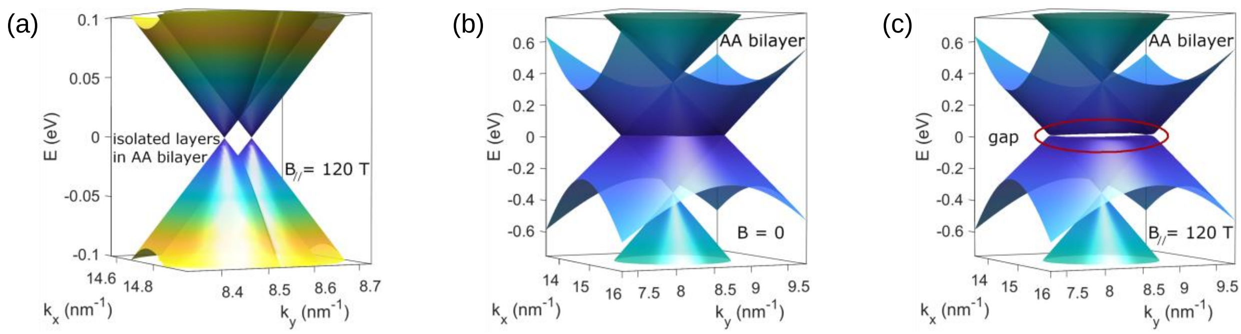

Figure 2: Energy bands around the Dirac point for an AA bilayer graphene and in the case of (a) isolated layers with in-plane magnetic field B=120 T, the Dirac point shift is proportional and orthogonal to the magnetic field; (b) coupled layers with B=0; (c) coupled layers with B=120 T, we observe the opening of a *k*-dependent gap varying up to about 33 meV and oriented in the reciprocal space according to the magnetic field direction.