Hofstadter-butterfly systems in superlattice of graphene

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Van der Waals heterostructures of graphene and hexagonal boron nitride feature a moire superlattice for graphene's Dirac electrons. A similar superlattice structure emerging in the graphene subjected to the magnetic field of an Abrikosov lattice of vortices in the underlying superconducting film. Here, we review the effects generated by different kinds of superlattices, including a specific miniband structure featuring gaps and secondary Dirac points, and a fractal spectrum of magnetic minibands known as Hofstadter's butterfly. Moreover, the experimental results are discussed as well.

References

[1] PHYSICAL REVIEW B 89, 075401 (2014)
[2] Nature Physics 10, 525–529 (2014)
[3] High-temperature quantum oscillations due to recurring Bloch states superlattices. To be published on Science
[4] Phys. Rev. B 94, 045442

Figures

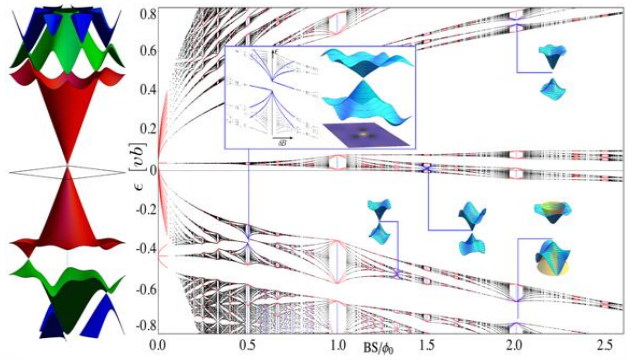

Figure 1: (Left panel) The B=0 minibands with a distinct secondary Dirac point (DP) in the valence band. The hierarchy of the Dirac-like spectrum, which is found by exact numerical diagonalization. Note that only the minibands generated from the lowest ten "Landau Levels" (LL) are shown. The numerical data is black dot. The red lines in the vicinity of zero magnetic field are the LLs of the first and secondary DP. The insets show examples of magnetic minibands, at simple fractions Bp/q = p φ0/S. For the Dirac-like spectrum in φ/φ0 = 1/2, the Berry curvature of the lower magnetic miniband is shown as a colour map inset.

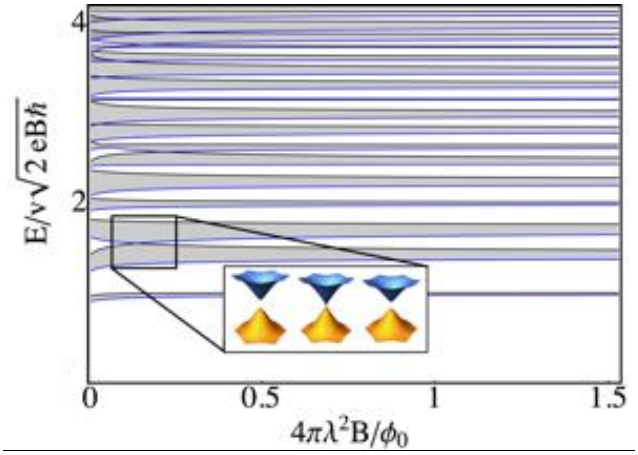

Figure 2: Spectrum of Dirac electrons in graphene in a magnetic field of an Abrikosov vortex lattice, with one degenerate band at E = 0. Both energy and the magnetic field are scaled. Inset: Second and third miniband dispersions over the folded magnetic Brillouin minizone near their touching condition.