Surface states in Bernal and rhombohedral graphite

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Recent technological progress have led to studies of high-quality hBN-encapsulated samples of graphite with Bernal or rhombohedral stacking [1]. These two stacking orders have notably different electronic properties: Bernal graphite is a metal with small electron and hole Fermi surfaces and no surface states; thin film of rhombohedral graphite is a topological insulator with insulating bulk and metallic surface states having complicated topology of Fermi surfaces.

We show that two types surface states do appear on the surface of Bernal graphite upon electrostatic doping, Fig. 1:
(1) compressible surface states that form a 2D metal on the surface (Fig. 1, left)
(2) incompressible surface states that appear above or below the Fermi level (Fig.1, right)
Under the influence of transversal magnetic field, the surface states of doped graphite turn into higher Landau level orbitals that appear at the surface, Fig. 2.

For surface states in rhombohedral graphite multilayers we calculate a phase diagram, predicting a pattern of gate-induced topological Lifshitz transitions, find a giant Berry curvature induced Hall coefficient and strong sensitivity of surface states to in-plane magnetic field [2]. The electronic dispersion and Landau levels in transverse magnetic field are shown in Fig. 3.

References

[1] J. Yin, S. Slizovskiy, Y. Cao, Sh. Hu, Y. Yang, I. Lobanova, B. Piot, S. Son, S. Ozdemir, T. Taniguchi, K. Watanabe, K. S. Novoselov, F. Guinea, A. K. Geim, V. Fal'ko ,A. Mishchenko, *Nature Physics* (2019), doi:10.1038/s41567-019-0427-6

[2] S.Slizovskiy, E. McCann, M.Koshino, V.Fal'ko, in preparation

Figures

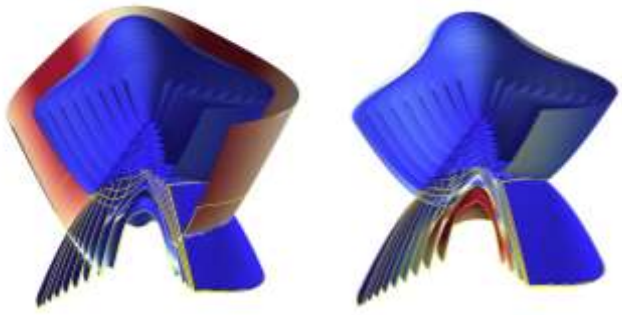

Figure 1: Dispersion of electrostatically doped Bernal graphite multilayer (as a function of in-plane momentum). Surface state branches are coloured in red. Left: type (1) surface states at doping $5{\cdot}10^{12}$ cm^{-2} ; Right: type (2) surface state at doping 10^{12} cm^{-2}

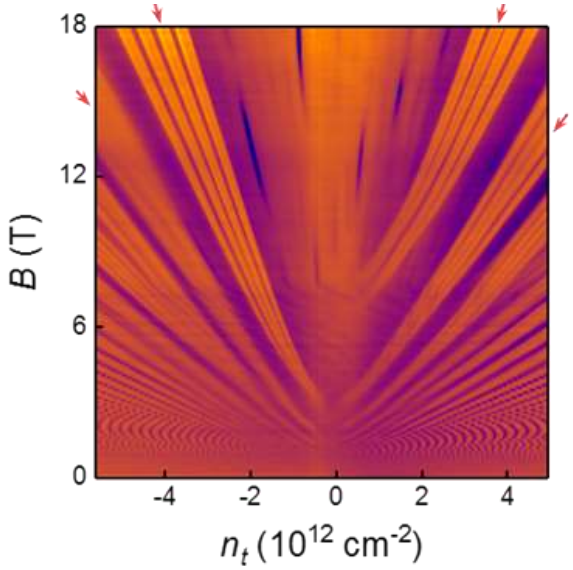

Figure 2: Conductance mapping of surface states in doped Bernal graphite [1].

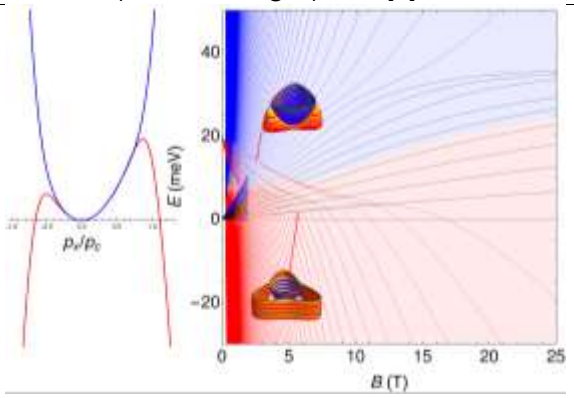

Figure 3: Dispersion and Landau levels of rhombohedral graphite [2].