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Landau levels of graphene multilayers in a parallel magnetic field

SERGEY PERSHOGUBA, VICTOR YAKOVENKO, University of Maryland at College Park — Much attention was paid recently to the Landau levels in graphene mono- and multilayers for a magnetic field perpendicular to the layers. In contrast to the previous investigations, we study the Landau levels of graphene multilayers (graphite) in a parallel magnetic field. We use the tight-binding approximation with the nearest-neighbor intralayer and interlayer hoping amplitudes γ_0 and γ_1 for the Bernal stacking. Electron dispersion is highly anisotropic in the plane perpendicular to the graphene layers and to the magnetic field. Employing numerical diagonalization and semiclassical approximations, we find the energy spectrum of the problem. The parabolic dispersion, well-known for graphene bilayers and multilayers without magnetic field, splits into an infinite series of Dirac cones due to the parallel magnetic field. These cones intersect and form a dispersive band around zero energy. The low energy levels exhibit an unusual Landau quantization $E_n \propto (nB)^2$, where n is a quantum number, and B is the magnetic field. We interpret these results in terms of closed semiclassical orbits on the two branches of the equienergetic surface. For the energies above $2\gamma_1$, the discrete energy spectrum transforms into a continuous dispersion $E(k)$, which corresponds to open semiclassical trajectories in the k-space.

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