Graphene in a Uniform Magnetic Field

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Abstract

We study monolayer graphene in a uniform magnetic field in the absence and presence of interactions. In the non-interacting limit for p/q flux quanta per unit cell, the central two bands (that eventually form the $n = 0$ Landau level) have $2q$ Dirac points in the Brillouin zone in the nearest neighbor model. These touchings and their locations are guaranteed by a combination of an anti-unitary particle-hole symmetry (chiral symmetry) and the lattice symmetries of the honeycomb structure. If we add a staggered potential (V_s) and a next nearest neighbor hopping (t_2) we find competition between t_2 and V_s leads to a topological phase transition. We also study the stability of the Dirac touchings to one-body perturbations that explicitly lower the symmetry.

In the interacting case In our study, we attempt to understand the phases in the strong magnetic field limit ($1/q$ flux where the q is finite and reasonably small). We consider on-site Hubbard interaction (U) and nearest-neighbor Heisenberg interaction (g). In the continuum limit, the theory has been studied before. It has been found that there exist four competing phases namely, ferromagnetic, antiferromagnetic, charge density wave, and Kekulé distortion phase (Kharitonov PRB 2012). We find phase diagrams for a different q where some of the phases found in the continuum limit are co-existent in the lattice limit. We also found some phases that are not present in the continuum limit.