Magnetic field response of graphene nanostructures

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We theoretically study the anomalous magnetic field response of graphene flakes and ribbons. The recent developments in fabrication techniques realized a variety of graphene nanostructures with various shapes and sizes. Here we show that a finite-sized graphene, or "a piece of Dirac metal", behaves in non-trivial manner in presence of magnetic field, due to the coexistence of massless Dirac spectrum and the quantum confinement. We show that the orbital magnetic susceptibility rapidly changes between diamagnetism and paramagnetism as a function of Fermi energy in accordance with the level structure. Remarkably, the total susceptibility varies in proportion to cube of the system size even though the system is two dimensional. The diamagnetism of graphene flakes is fairly strong and can be observed using the magnetic field alignment in a solvent. When graphene flakes are randomly stacked in the perpendicular direction, the whole system exhibits an analogue of Meissner effect, where the external magnetic field is significantly screened inside the sample.

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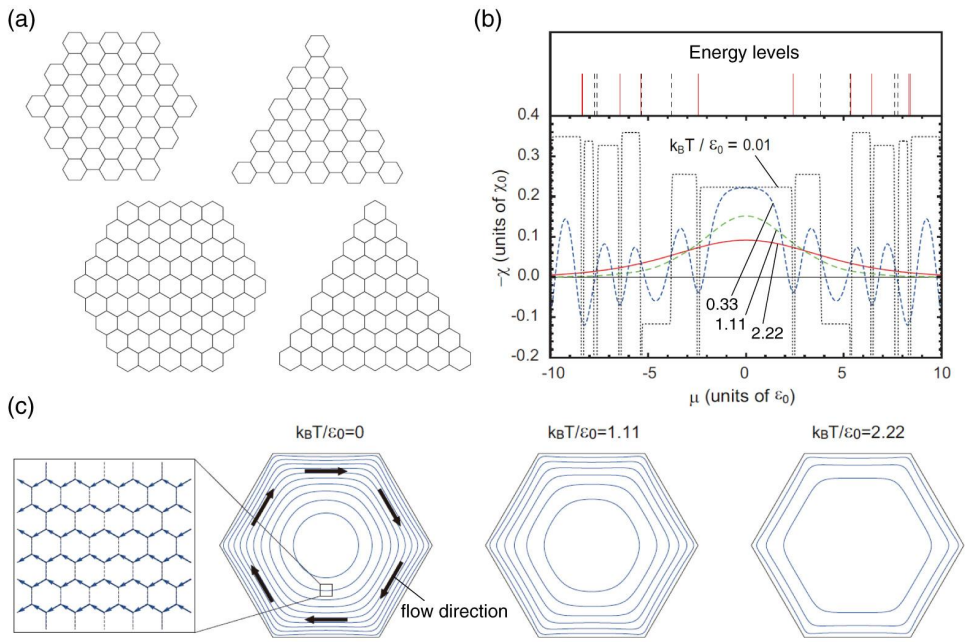
[2] Y. Ominato and M. Koshino, arXiv:1301.5440v1 (2013).
[3] M. Koshino and T. Ando, Phys. Rev. B 81, 195431 (2010).



(a) Atomic structures of graphene flakes. (b) Orbital magnetic susceptibility as a function of the chemical potential of a hexagonal armchair graphene flake. (c) Diamagnetic current distribution in a hexagonal graphene flake in several different temperatures.