Manipulating Dirac cones in Graphene by periodic ac fields

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In the last years, the search for topological effects in condensed matter systems has become a prior task. Graphene, because of its striking band structure, is an excellent platform to explore two-dimensional relativistic physics and topological phases. Topological transitions between semi-metallic and insulator phases are predicted to occur when the two inequivalent Dirac cones merge[1, 2] . The merging is achieved by introducing anisotropy in the honeycomb lattice, usually by mechanical means. However, the difficulties to properly control mechanically the anisotropy motivate the search of new methods, more controllable and non- destructive. We propose a theoretical model of graphene driven by an AC electric field, and show that such a driving allows for the manipulation of the Dirac cones in a high frequency limit. Their merging leads to rich diagrams with different semi-metallic and insulating phases topologically distinct. Furthermore, AC field-induced charge localization in selective spatial directions is found to occur at the transition between two insulating or two semi-metallic phases. In addition, we demonstrate that for low frequency driving, non-linear polarization breaks time reversal and particle-hole symmetry, allowing for new topological phases[3].

Fig.1: (a) Phase diagram of graphene under a high frequency electric field elliptically polarized. Several insulating (I) or semi-metallic (SM) phases are found when tuning the phase shift between the x and y field components and the amplitude of the field in the y direction. The topological phase transitions between the I and SM phases can occur only at one of the four time-reversal symmetric points of the Brillouin zone where a pair of Dirac point is created/annihilated (M0 – M3). At such a transition the dispersion relation is linear in one direction but quadratic in the other one (c). In addition, certain insulating phases are found to be topologically non-trivial, (b) and (d), and host zero energy edge states protected by chiral symmetry (ZI1 and ZI2). The transition between two insulating or SM phases is characterized by a flat dispersion relation in one direction whereas it reminds linear in the other direction (e).

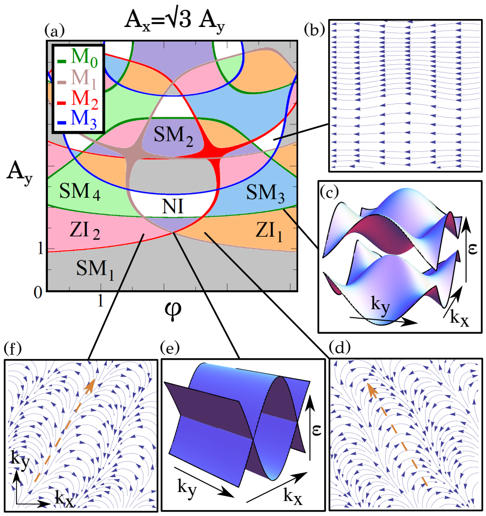

Figure 1:

*References

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