Chiral Symmetry and Electron-Electron Interaction in Many-Body Gap Formation in Graphene

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Graphene with its Dirac cone dispersion becomes particularly interesting when one takes many-body effects into account. On the one-body level it is well-known that the chiral symmetry associated with the bipartite honeycomb lattice guarantees a topological stability of the doubled Dirac cones against finite perturbations. When the electron-electron interaction is switched on, the chiral symmetry again plays a crucial role. Although several possible many-body states have been proposed as the origin of gap opening of the $n = 0$ Landau level for high magnetic fields, no clear consensus has been reached thus far. Using the exact diagonalization method, we have investigated this with the extended Hubbard model for spinelss fermions on the honeycomb lattice [1]. By fully utilizing the chiral symmetry of the zero modes, we have obtained a perturbatively exact ground state for the half-filled $n = 0$ Landau level (only the $n = 0$ subspace is taken into account). Examination of the non-Abelian Chern number implies the ground state is a Hall insulator with a topological degeneracy of $N_D = 2$. "Bond order" formation [2] and exsistence of the edge states are discussed from a view point of the bulk-edge correspondence.

[1]Y. Hamamoto, Y. Hatsugai, and H. Aoki, to be published.
[2]Y. Hatsugai, T. Fukui, and H. Aoki, Physica E **40**, 1530 (2008).