

Electromagnetic response and pseudo-zero-mode Landau levels of bilayer graphene in a magnetic field

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Graphene attracts a great deal of attention, both experimentally and theoretically, for its unusual electronic transport. Of particular interest is bilayer graphene, which has a unique property that the energy gap between the conduction and valence bands is controllable by use of external gates or chemical potential.

In the symposium we would like to report, on the basis of our recent paper [1], our study of the electromagnetic response of bilayer graphene in a magnetic field, in comparison with that of monolayer graphene. We shall focus on the following points:

(1) The particle-hole picture of the vacuum state is one of the basic features specific to graphene, and even the vacuum state acts as a dielectric medium. The dielectric effect turns out to be generally much more sizable for bilayers than monolayers.

(2) The presence of the zero-(energy-)mode Landau levels is another feature specific to graphene. In bilayer graphene external gates act to open a band gap between the (pseudo-)zero-mode levels at the two valleys and, unlike in monolayers, their effects become visible in density response.

(3) We point out that in bilayer graphene the splitting of some specific nearly-degenerate Landau levels, whose degeneracy is related to a nonzero index of the bilayer Hamiltonian, is also externally controlled by an inplane electric field or by an injected Hall current. It will be possible to observe this field-induced gap via the quantum Hall effect with an injected current; one would be able to resolve the $\nu = \pm 2$ Hall plateaus thereby.

[1] T. Misumi and K. Shizuya, preprint arXiv:0803.2452, to appear in PRB.