DAY 2: 10:50 – 11:30

Controlling the electronic valley degree of freedom in graphene systems

Qian Niu
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The band structure of graphene has energetically degenerate valleys at the two nonequivalent corners of the Brillouin zone. Because of their large separation in momentum space, inter-valley scattering is strongly suppressed, implying the potential use of valley degree of freedom (valley index) in a manner similar to the use of spin in spintronics applications. Interesting valley dependent phenomena and their possible applications, dubbed as 'valleytronics', are being actively explored. Recently, we discovered a general scheme to generate and detect valley polarization (difference in electron concentrations in the two valleys) in graphene systems with broken inversion symmetry, which occur in epitaxially grown graphene and in biased graphene bilayers. Here I report a systematic study of magnetic, electrical and optical control on the valley degree of freedom of electrons in such graphene systems.

DAY 2: 11:30 – 11:50

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 trasport. 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 dielctric 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 releted 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.