# CU Physics Department Colloquium

**Monday, October 24, 2011 4:10 PM 428 Pupin Hall**

# Strain-dependent topology of electron bands in bilayer graphene

Electrons in bilayer graphene exhibit quite unusual properties: they can be viewed as `massive chiral fermions' with parabolic dispersion at intermediate energies and Berry phase 2π, in contrast to monolayer graphene, where electrons are Berry-phase π quasi-particles with linear dispersion. Here, we show that topology of the low-energy band structure of electrons in bilayer graphene critically depends on mechanical deformations of the crystal. Strain is naturally generated in suspended graphene devices, due to motion of the supporting contacts upon cooling, depending on the device geometry or preparation history. Strain determines the number of Dirac cones in the low-energy part of the spectrum, below the saddle point in the electron dispersion: two with the Berry phases in a strongly strained crystal instead of four (three with Berry phase π and one with -π) in an unperturbed crystal. In physics of metals, such change in topology of band structure is known as the Lifshitz transition. These spectral features are tracked down to the evolution of the Landau levels for electrons in a magnetic field and we predict their manifestation in the quantum Hall effect in strained bilayers. Finally, the electron-electron interaction in unperturbed bilayer graphene may lead to a correlated state with a spontaneously broken symmetry. Theoretical analysis based upon the renormalisation group approach which takes into account all possible symmetry-breaking interaction channels shows that the strongest instability in the electronic liquid in bilayer graphene develops into the state with anisotropic interlayer hopping of electrons which mimics the effect of uniaxial strain. As a result, the experimental consequences of the nematic phase transition of electrons would look similar to those of strain, however, in suspended graphene devices these would not depend on the device geometry or preparation history.

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