Quantum Hall ferromagnetism in graphene on hexa-Boron Nitride substrates

A.F. Young[a], C.R. Dean[b], K.L. Shepard[b], J. Hone[c], and P. Kim[a]

[a]Department of Physics, Columbia University
[b]Department of Electrical Engineering, Columbia University
[c]Department of Mechanical Engineering, Columbia University

In graphene, the structure of the honeycomb lattice endows the wavefunctions with an additional quantum number, termed valley isospin, which, combined with the electron spin, yields four-fold degenerate, approximately SU(4) symmetric LLs. The expanded degenerate Landau level manifold makes a wide variety of symmetry breaking ordered states possible; an outstanding question of fundamental interest is which ones nature chooses, which excitations such states support, and to what extent these states can be manipulated.
In this paper, I will present recent experimental data obtained on high quality graphene devices fabricated on hexagonal Boron Nitride substrates, focusing on the broken symmetry integer quantum Hall regime. In graphene/hBN devices, all integer plateaus are observed at fields of a few tesla. This allows us to probe the transport of spin textured excitations through the application of an in-plane field, which tunes the Zeeman energy. I will show that for half-filled quartet Landau levels (filling factors $\nu = 4, 8, 12$), with the exception of ν=0, the ground state is spin polarized and supports spin-flip excitations. At $\nu = 4$, these excitations contain multiple spins, suggesting that charge is carried by Skyrmions. At $\nu = 0$, in contrast, I will argue that the ground state is not spin polarized.