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Collective mode excitations of the $\nu = 0$ QH state in graphene YAFIS BARLAS, University of California at Riverside — In high magnetic fields, graphene at the charge neutrality point ($\nu = 0$) becomes an insulator. This is due to valley-dependent interactions within the zeroth Landau level (LL) that result in canted anti-ferromagnetic (CAF) spin ordering. As the Zeeman energy is increased, the CAF state transitions to a quantum Hall ferromagnetic state, with symmetry protected counter-propagating edge modes. This non-local signal has been verified in tilted-fields. Using a microscopic model with valley-dependent interactions in the zeroth LL, we derive an effective $SU(4)$ spin model Hamiltonian for $\nu = 0$ QH state. We use this model to calculate the collective valley and spin excitations in the $\nu = 0$ QH state. In the long wavelength limit, the collective spin and valley excitation energies scale as $\omega \sim vq$, in the $\nu = 0$ CAF state. We also calculate the energy of the neutral topological spin and valley Skyrmions in the $\nu = 0$ QH state. The role of the collective mode excitation on the spin and valley transport in the $\nu = 0$ insulating QH state will be addressed.

Yafis Barlas
University of California at Riverside

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