Abstract Submitted
for the MAR15 Meeting of
The American Physical Society

Collective Edge Modes near the onset of a graphene quantum spin Hall state GANPATHY MURTHY, Department of Physics and Astronomy, University of Kentucky, Lexington KY 40506-0055, USA, EFRAT SHIMSHONI, Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel, HERBERT FERTIG, Department of Physics, Indiana University, Bloomington, IN 47405, USA — Graphene subject to a strong, tilted magnetic field exhibits an insulator-metal transition tuneable by tilt-angle, which is attributed to the transition from a canted antiferromagnetic (CAF) to a ferromagnetic (FM) bulk state at filling factor $\nu = 0$. We develop a theoretical description for the spin and valley edge textures in the two phases, and the implied evolution in the nature of edge modes through the transition. Based upon numerical Hartree-Fock calculations, we derive a simple description of the spin-valley domain wall for arbitrary Zeeman energy E_z, parameterized by *two* canting angles. Low-energy charged excitations can be constructed by imposing a slowly varying spin rotation on this state. In the CAF, these involve binding a vortex (meron) of the bulk state to a spin twist at the edge, so that the *bulk* spin stiffness controls the excitation energy. As the CAF-FM transition is approached ($E_z \to E_z^c$), the bulk stiffness vanishes linearly with ($E_z^c - E_z$) and the vortex unbinds from the edge, yielding a gapless edge excitation characteristic of a quantum spin Hall state. Our model predicts the E_z-dependence of the activation gap in edge transport, and offers a qualitative picture of how this transport should evolve with filling factor.

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Date submitted: 10 Nov 2014 Electronic form version 1.4