Electrically switchable tunneling across a graphene pn junction: evidence for canted antiferromagnetic phase in = 0 state

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Abstract

The ground state of a graphene sheet at charge neutrality in a perpendicular magnetic field remains enigmatic, with various experiments supporting canted antiferromagnetic, bond ordered, and even charge density wave phases. A promising avenue to elucidate the nature of this state is to sandwich it between regions of different filling factors, and study spin-dependent tunneling across the edge modes at the interfaces. Here we report on tunnel transport through a = 0 region in a graphite-gated, hexagonal boron nitride (hBN) encapsulated monolayer graphene device, with the = 0 strip sandwiched by spin-polarized = ± 1 quantum Hall states. We observe finite tunneling (t $\sim 0.3 - 0.6$) between the = ± 1 edges at not too small magnetic fields (B $>$ 3T) and low tunnel bias voltage ($<$ $30 - 60\mu$V), which is surprising because electrons at the edge states nominally have opposite spins. Hartree-Fock calculations explain these phenomena as being driven by the formation of a CAF order parameter in the = 0 region at zero bias (for wide enough junctions) leading to non-orthogonal spins at the edges. Remarkably, this tunneling can be controllably switched off by increasing bias; bias voltage leads to a pileup of charge at the junction, leading to a collapse of the CAF order and a suppression of the tunneling.

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