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Spin-Valley Coherent Phases of the nu=0 Quantum Hall State in Bilayer Graphene

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Bilayer graphene subjected to magnetic and electric fields exhibits a plethora of phases with radically distinct behaviors. Most prominently, the nu=0 quantum Hall state which develops at zero doping manifest a rich phase diagram marked by changes in the electrical conductance, and is tunable by either of the external fields. This behavior is attributed to the variety of many-body states with broken symmetry, which can form due to the multicomponent nature of the discrete degrees of freedom (spin, valley and orbital isospin). In particular, in the presence of a perpendicular electric field D, at least two distinct insulating phases are identified: a canted antiferromagnet (CAF) at low D, and a fully layer polarized (FLP) phase at low D. However, at intermediate values of D and the magnetic field B, a finite conductance is developed, potentially indicating the formation of novel intermediate phases. I present a theoretical study [1] motivated by these observations, which accounts for the interplay between lattice-scale interactions, inherently anisotropic in the spin-valley-orbital manifold, and a (formerly overlooked) trigonal warping effect in the electronic band-structure. Employing a Hartree-Fock calculation, we find several competing many-body states characterized by unusual spin-valley entangled correlations, which are promising candidates for the ground-state at intermediate fields. Most interestingly, we find a regime of parameters where the emergent intermediate phase is characterized by a simultaneous breaking of two distinct U(1) symmetries. I further discuss the implications on transport properties; most remarkably, the emergence of high conductance is a possible signature of robust collective edge modes associated with textures in the spin/valley manifold, which are topological in nature.

[1] G. Murthy, E. Shimshoni and H.A. Fertig, Phys. Rev. B 96, 245125 (2017).