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Isospin phase transitions and superconductivity in Bernal bilayer and rhombohedral trilayer graphene

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Of the zoo of graphene-based layered systems, my presentation touches on Bernal bilayer and rhombohedral trilayer graphene, where the low-energy continuum theory is described by four-fold (valley and spin) degenerate gapless electronic bands, exhibiting quadratic and cubic band touching, respectively. Recent experiments shed light on a cascade of degeneracy lifting phase transitions in both systems, when subjected to chemical doping and external electric displacement field. I propose a simple explanation for these isospin phase transitions, based on the interplay between the experimentally tunable chemical doping and electric field, and interaction induced competing phases. Curiously, while trilayer graphene readily exhibits multiple distinct superconducting regions without any applied magnetic field, bilayer graphene requires the presence of in-plane magnetic field to display pairing. I propose that the two prominent pairing phases in trilayer graphene are conventional s-wave and spin-triplet f-wave in nature, while that in bilayer graphene is a spin-triplet f-wave superconductor. I demonstrate the emergence of these superconducting orders from the adjacent excitonic parent states via a leading-order renormalization group calculation. The nature of pair-density-wave ordering in rhombohedral trilayer graphene will also be highlighted.

[1] A. Szabó and B. Roy, Metals, fractional metals, and superconductivity in rhombohedral trilayer graphene, PRB 105, L081407 (2022).
[2] A. Szabó and B. Roy, Competing orders and cascade of degeneracy lifting in doped Bernal bilayer graphene, arXiv:2111.15673 (2021).