Fluctuating Magnetism in Rhombohedral Graphene Multilayers

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Graphene flat band systems are an ideal test bed for understanding the role of intinerancy and localization in ferromagnets. In particular, magnetism is observed as a function of gate voltages and other tuning parameters both in twisted bilayer graphene—where the moire superlattice plays a critical role—as well as crystalline rhombohedral layers where no localized bands are present near the Fermi energy. This allows one-to-one comparisons of the role of the moire lattice in magnetism.

We study the electronic compressibility, proximal exciton sensing response, and electronic transport measurements of Bernal Bilayer Graphene (BBG) and Rhombohedral Trilayer Graphene (RTG) devices. While magnetic ordering[1-5]—observed most clearly via the onset of the anomalous Hall effect in valley polarized phases—occurs only below 2-3K, we find a fluctuation regime persisting to temperature more than one order of magnitude higher. Magnetic fluctuations dominate the thermodynamic response at high temperature: from compressibility measurements, we detect a large excess entropy of ~0.1k_B/charge carrier which we attribute to fluctuating isospin domains as small as ~10 carriers. We provide further evidence for large isospin entropy in the vicinity of a quantum phase transition between isospin ordered and disorderd states: increasing temperature can favor the formation of a fluctuating ordered phase, analogous to a the Pomeranchuk effect in 3He.

These thermodynamic features are remiscent of similar effects in twisted bilayer graphene. However, we find a striking difference in the transport properties. In both BBG and RTG, we observe a decreasing resistance with increasing temperature throughought the fluctuation regime, a highly unusual behavior for metals. The negative temperature coefficients lead to a minimum of R(T) within the fluctuation phases of around 10-20K. We connect the negative dR/dT to the fluctuation regime and discuss possible mechanisms.

Category:

4. Carbon: 2D graphene, 1D nanotubes, and 0D quantum dots.

References

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