Microwave resonance as a spin-probe in flatband graphene systems

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In strongly correlated two-dimensional systems, collective excitations reveal crucial information regarding the electronic order of the underlying ground state. However, a direct observation of collective excitations in flatland graphene systems has not yet been realized due to the lack of a spin probe. Here we demonstrate that the resistively-detected electron spin resonance (RD-ESR) technique can directly observe collective modes in the form of microwave-induced resonance near half-filling of the moire flatband [1]. The frequency-magnetic field dependence of these resonance modes enables the extraction of key parameters such as intervalley exchange interaction. Two independent observations show that the generation and detection of microwave resonance relies on the strong correlations within the flat moiré energy band. First, the onset of the resonance response coincides with the spontaneous flavour polarization at moiré half-filling, but is absent in the isospin unpolarized density range. Second, we perform the same measurement on various systems that do not have flat bands and observe no indication of a resonance response in these samples. The ability to directly probe the spin order using transport provides a powerful method to investigate strongly correlated electrons in van der Waals heterostructures. For example, I will discuss our recent measurement of spin resonance in Bernal bilayer graphene and its implication on electronic orders in moiréless graphene systems.

References

1. E. Morissette, J.X. Lin, D. Sun, *et al.*, *Nature Physics*, 19 (2023) 1156-1162

Figures

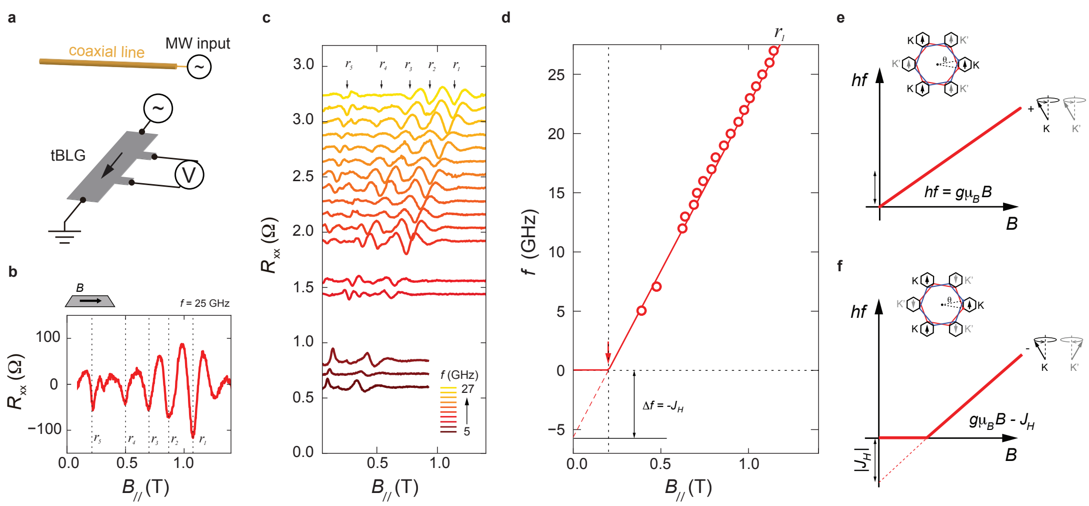

Figure 1: **(a)** Schematic of the resistively-detected electron spin resonance (RD-ESR) measurement setup. Microwave signals between 1-30 GHz pass through the coaxial line above the sample, while transport resistance is measured at a near-d.c. frequency of 17 Hz. **(b-c)** Microwave resonance features manifest as changes in the longitudinal resistance as a function of MW frequency and magnetic field. **(d)** The primary resonance feature (r_1) extrapolates to a negative intercept in the energy *hf* versus *B* trajectory. Schematics of trajectories for **(e)** ferromagnetic coupling where spins are aligned in opposite valleys and along the external magnetic field, and **(f)** antiferromagnetic coupling, which is in excellent agreement with the observed behavior of r_1.