Magnetic order in a coherent two-dimensional Kondo lattice

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Kondo lattices are ideal testbeds for the exploration of heavy-fermion quantum phases of matter. While our understanding of Kondo lattices has traditionally relied on complex bulk *f*-electron systems, transition metal dichalcogenide heterobilayers have recently emerged as simple, accessible and tunable 2D Kondo lattice platforms where, however, their ground state remains to be established. Here we present evidence of coherent magnetism in the 1T/1H-$TaSe_2$ heterobilayer by means of scanning tunneling microscopy/spectroscopy at 340 mK. Our measurements reveal the existence of two symmetric electronic resonances around the Fermi energy, a hallmark of coherence in the spin lattice. Spectroscopic imaging locates both resonances at the central Ta atom of the charge density wave of the 1T phase, where the localized magnetic moment is held. Furthermore, the evolution of the electronic structure with the magnetic field reveals a non-linear increase of the energy separation between the electronic resonances. Aided by ab initio and auxiliary-fermion mean-field calculations, we demonstrate that this behavior is inconsistent with a fully screened Kondo lattice, and originates instead from a ground state with magnetic order mediated by conduction electrons. The manifestation of magnetic coherence in TMD-based 2D Kondo lattices enables the exploration of magnetic quantum criticality, Kondo breakdown transitions and unconventional superconductivity in the strict two-dimensional limit.

References

[1] Wen Wan, *et al*., arxiv:2207.00096v2 (2022)

Figures

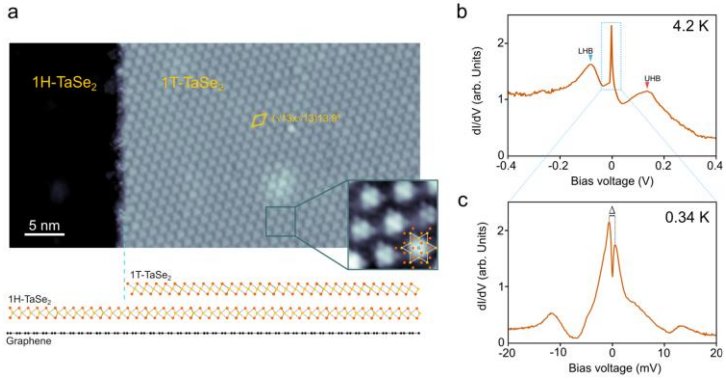

Figure 1: Atomic and electronic structure of the 1T-$TaSe_2$/1H-$TaSe_2$ heterobilayer. a, Large-scale STM image of a monolayer of 1T-$TaSe_2$ on monolayer 1H-$TaSe_2$ grown on BLG/SiC(0001). Below a sketch of the vertical arrangement of the atomic layer is shown. The inset shows a high-resolution STM image of the CDW supercell, where a sketch of the CDW Star of David is overlaid. **b**, Typical dI/dV spectrum taken on the 1T/1H heterostructure at 4.2 K. The position of the lower (upper) Hubbard band is indicated. **c**, Low-bias dI/dV spectrum acquired on the 1T/1H heterostructure at our base temperature of 0.34 K showing the emergence of two peaks, a hallmark of quantum coherence.