Atomic-scale investigations of Kondo systems

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Single magnetic adatoms on surfaces are prime examples for quantum spin systems with a large degree of control over the atomic-scale environment. Here, we use scanning tunneling spectroscopy to investigate magnetic adatoms on a monolayer of MoS_2 on Au(111), where the moiré modulated density of states at the interface provides a versatile platform for tuning the exchange coupling to the metallic substrate. We find pure spin excitations in Fe adatoms adsorbed on the minima of the moiré structure, characteristic of negligible exchange and dominant single-ion anisotropy, whereas Fe atoms on the moiré maxima exhibit a fully developed Kondo resonance, indicating strong exchange and negligible single-ion anisotropy [1].

The variations in exchange coupling evoked by the moiré structure are also present for individual Mn atoms on MoS_2 on Au(111). In this system, we explore the interatomic exchange coupling when two atoms are brought into sufficiently close distance. At a separation of a few lattice sites, the interaction is dominated by substrate-mediated exchange, while nearest neighbor sites lead to direct exchange coupling and a molecular-singlet ground state. The singlet-triplet transition probed by tunneling electrons is again very sensitive to the relative adsorption of the dimer with respect to the moiré structure. We ascribe these variations to renormalization of the interatomic exchange imposed by the electronic moiré variations in the surrounding [2].

We finally also investigate the putative Kondo lattice in the van der Waals ferromagnet Fe_3GeTe_2. All across the surface, we find a small gap on top of a Fano resonance. While the latter is characteristic of Kondo screening the former signifies the hybridization gap, corroborating the earlier suggestion of Kondo-lattice formation [3]. Magnetic adatoms do not influence the correlated state of the substrate [4].

References:

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