Kondo lattice development in a TaS_2 van der Waals heterostructure

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Kondo screening occurs when a magnetic impurity is embedded in a metal, below a given temperature, known as the Kondo temperature, a singlet state forms between the spin of the impurity and the spins of the conduction electrons [1]. When the distance between the magnetic impurities is small enough the physics of the system is expected to be modified [2]. The first experimental evidence was obtained in the 1970s in systems containing rare earths [3]. By means of scanning tunneling microscopy (STM) and spectroscopy (STS) at low temperatures we explore a van der Waals heterostructure consisting in a single layer of 1T-TaS_2 on a 2H-TaS_2 crystal. The 1T-TaS_2 layer presents a $\left(\sqrt{13}\times\sqrt{13}\right)R13.9°$ charge density wave (CDW) with a localized electron at the center of every unit cell of the CDW. For temperatures below 28K the spatially resolved STS shows the presence of a Kondo resonance in the Mott-Hubbard gap. For temperatures below 11K the system develops a quantum coherent state called Kondo lattice.

References

[1] J. Kondo, Prog. Theor. Phys. 32 (1961) 41
[2] P. Nozieres, Ann. Phys. 10 (1985), 19
[3] W.R. Johanson, G.W. Crabtree, A.S. Edelstein, O.D. McMasters, Phys. Rev. Lett. 46 (1981) 504

Figure

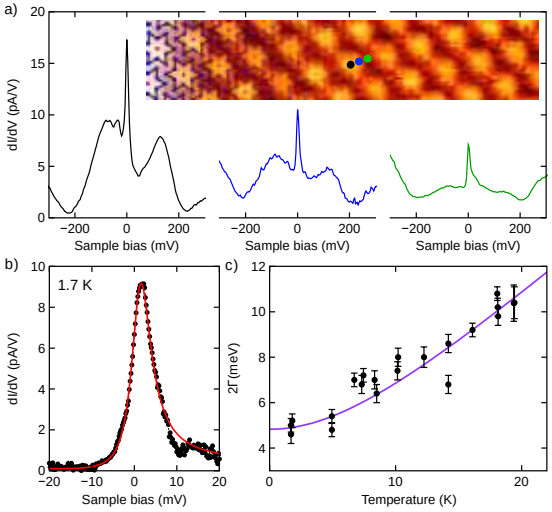

Figure 1: a) Single point STS taken on different locations along the CDW unit cell showing the modulation of the intensity of the zero bias Kondo peak. The Kondo resonance is more intense at the centre of the CDW unit cell (black spectrum) and decays very fast away from the centre (blue and green spectra). STS parameters: 500 mV, 500 pA, Vmod=5 mV. The inset shows the area of the sample where the spectra were measured, with the STS locations colored accordingly. Image parameters: 500 mV, 90 pA, 20 nm x 4 nm. b) Individual spectrum belonging to the temperature series of the panel c), in this case the spectrum is taken at T=1.7 K and fitted with a Fano function taking into account the broadening produced by temperature and the lock-in modulation. c) Plot showing the dependence with temperature of the intrinsic full width at half maximum (FWHM) of the Kondo resonance, and corresponding fit to the expected behaviour according to the Fermi liquid theory, giving a Kondo temperature of T_K=27 K.