# Electronic properties of a 1H/1T/2H-TaS2 polymorphic vdW heterostructure

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1H/1T-TaS2 heterostructures were first studied in 4Hb-TaS2 crystals in the decade of the 90s [1,2]. More recently, in 1T-TaS2 crystals and HOPG, an increase in the superconducting (SC) critical temperature has been reported [3,4]. In this work we study a 1H/1T heterostructure in a 2H-TaS2 crystal and, contrary to previous publications, no increase in the SC critical temperature is found. Instead, a non-SC gap appears in the local density of states of the 1H/1T heterostructure (see green dotted lines in figure 1C), possibly hindering the expected boost in critical temperature. The variation with temperature and magnetic field together with the shape of the gap allow us to trace back its origin to the long-range interaction between electrons close to the Fermi level [5]. Another intriguing property of this material is the transparency of the metallic 1H layer to the CDW of the 1T layer underneath [1,2], that results in strongly bias dependent STM images where both CDWs can be detected simultaneously (see panels a and b of figure 1). Our STS data (panel c) allow us to explain this effect as a direct tunneling process to the upper Hubbard sub-band of the 1T layer underneath (see purple arrow in figure 1C).

## References

[1] I. Ekvall and J. J. Kim, Phys. Rev. B 55, 11 (1997)
[2] W. Han, E. R. Hunt, O. Pankratov and R. F. Frindt, Phys. Rev. B **50**, 19 (1994)
[3] Z. Wang et al., ACS Nano **12**, 12 (2018)
[4] V. Vano et al., Nature **599**, 582 (2021)
[5] A.L. Efros, B. Skinner, B.I. Shklovskii, Phys. Rev. B **84**, 064204 (2011)

## Figures

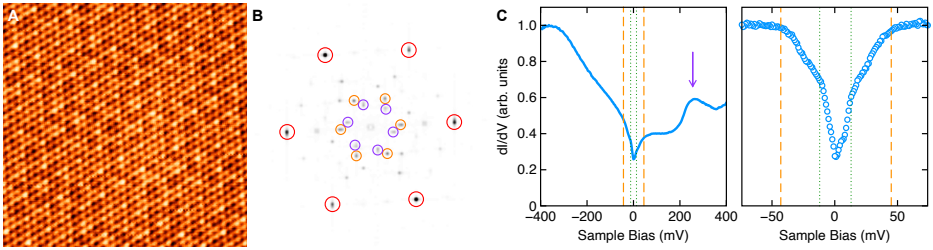


**Figure 1:** **A:** Atomic resolution STM image of 1H/1T/2H TaS2 recorded at 1.2 K. Image parameters: V=100 mV, I=300 pA, size: 10 x 10 nm$^2$. **B:** FFT map corresponding to the image of panel A. Red, orange and purple circles mark the 1st order spots of the atomic lattice, 1H CDW and 1T CDW respectively. **C:** STS spectra recorded over 1H/1T/2H TaS2 at 1.2 K. Orange dashed lines mark the onset of the pseudo-gap associated to the 1H CDW, and the purple arrow points to the upper Hubbard sub-band from the 1T layer underneath. Right panel has been background-subtracted.