Artificial heavy fermions in a van der Waals heterostructure

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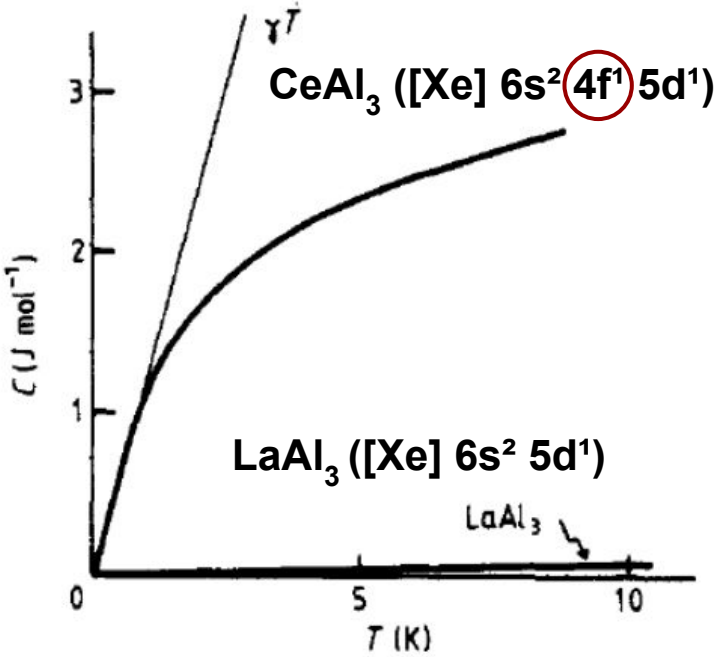
12/2/21

References:

- **Vaňo, V., Amini, M., Ganguli, S.C. et al. Artificial heavy fermions in a van der Waals heterostructure. Nature 599, 582–586 (2021). https://doi-org.stanford.idm.oclc.org/10.1038/s41586-021-04021-0**

Background: Heavy Fermions

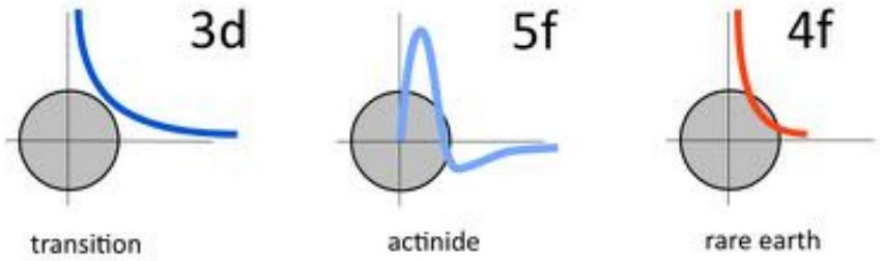


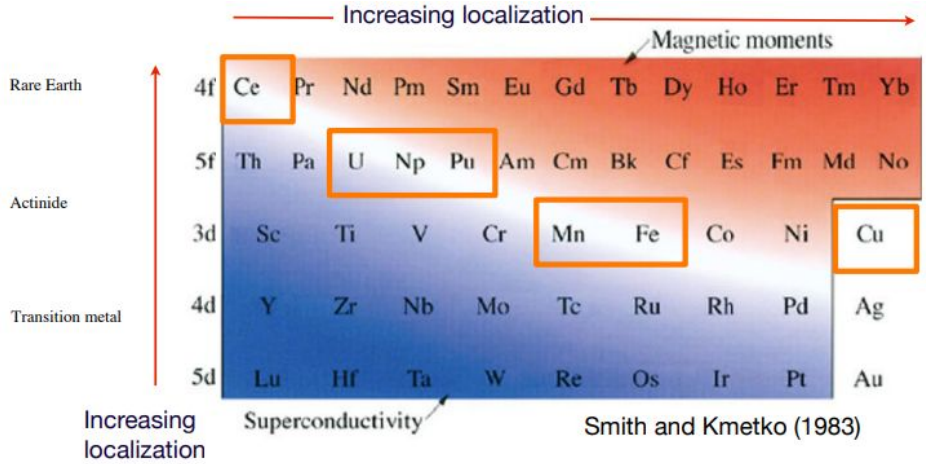
$$C = C_e + C_{ph} = \gamma T + AT^3$$

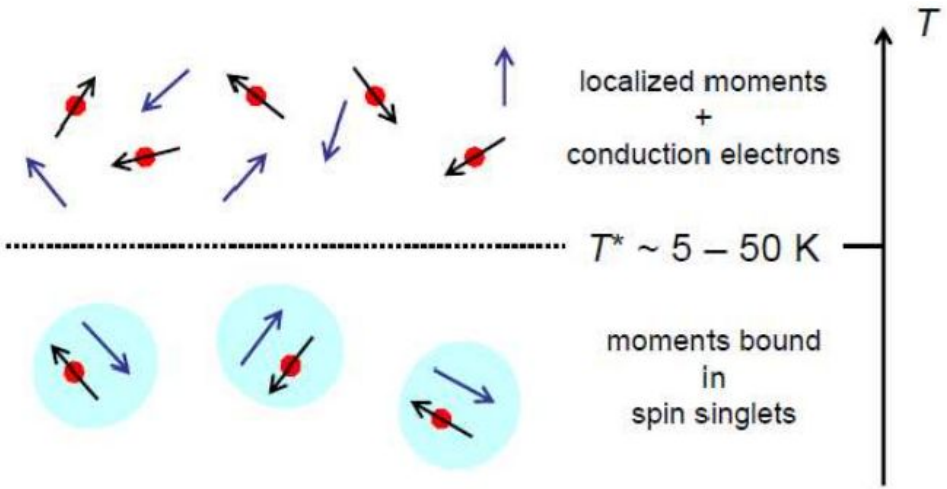
$$\gamma = \frac{1}{3}\pi^2 \frac{Nk^2}{\varepsilon_f} = \frac{1}{3}\pi^2 Nk^2 \left(\frac{2m}{\hbar^2}\right)\left(3\pi^2 \frac{N}{V}\right)^{-2/3}$$

Effective mass renormalization $m^*/m_e \sim 1000$!

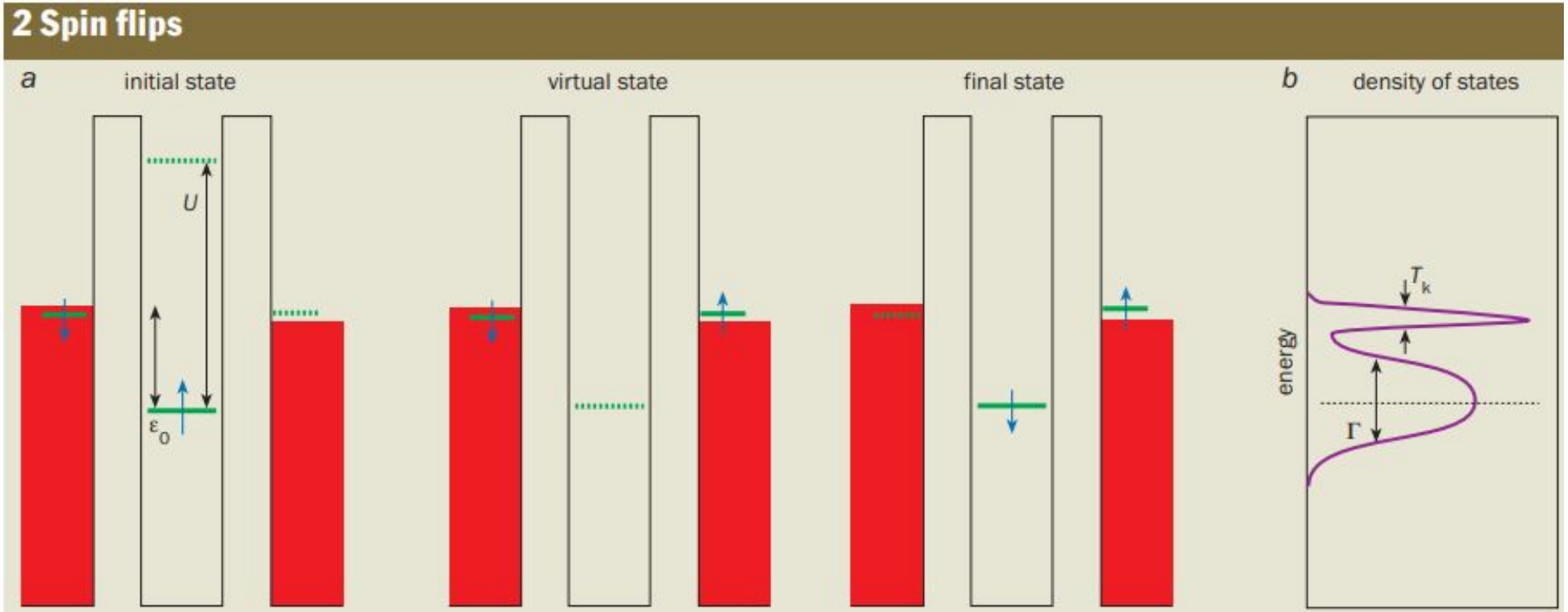
Background: Heavy Fermions



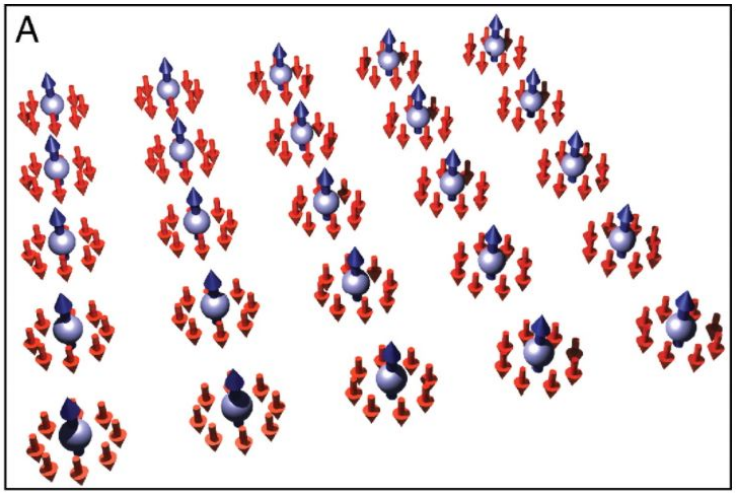


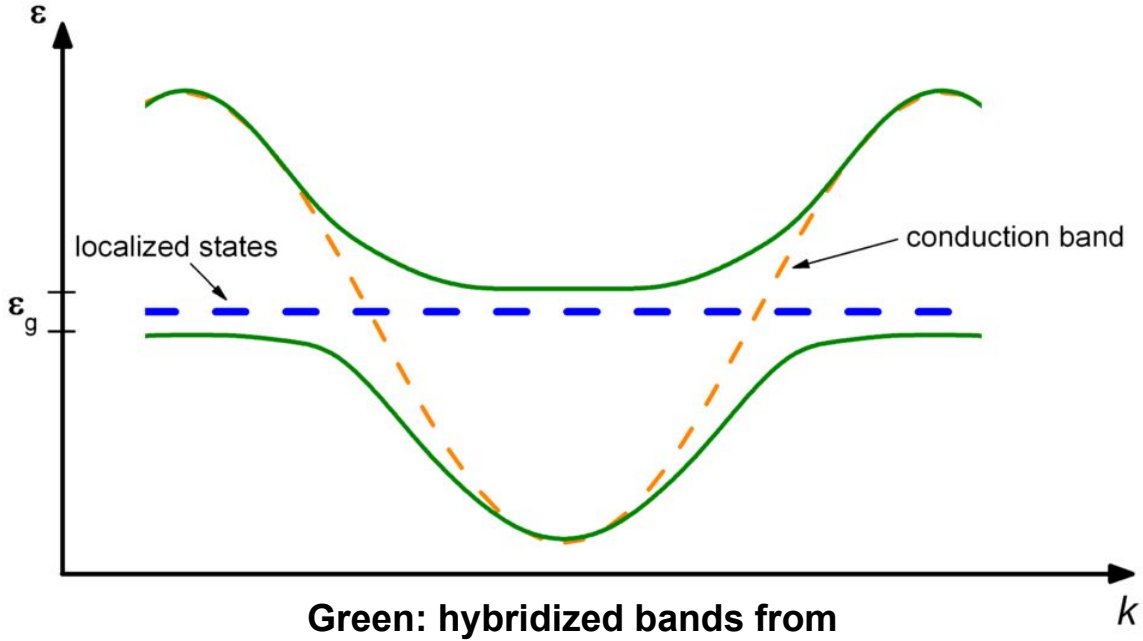


Background: Kondo Resonance



Background: Kondo Lattice

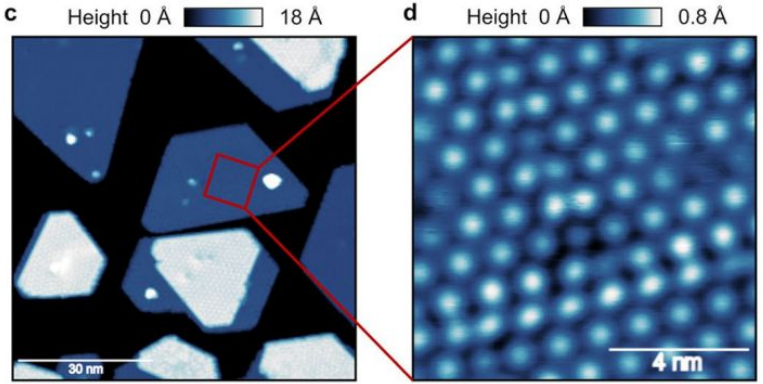


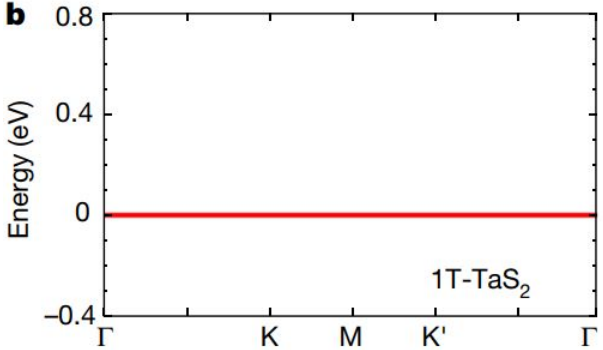


Green: hybridized bands from localized f-states and conduction sea, opens gap (signature of heavy fermion materials)

Material

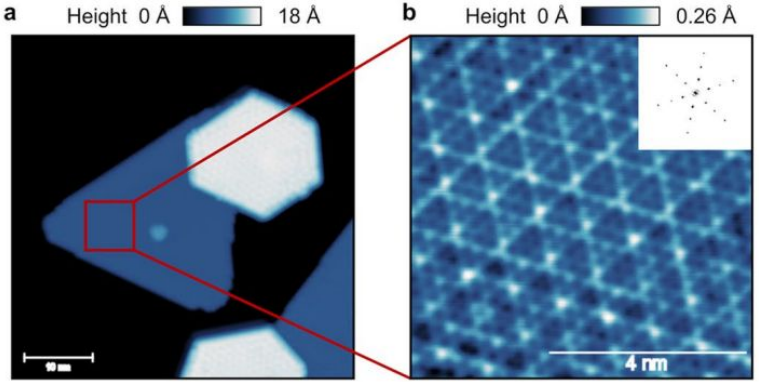
1T-TaS2

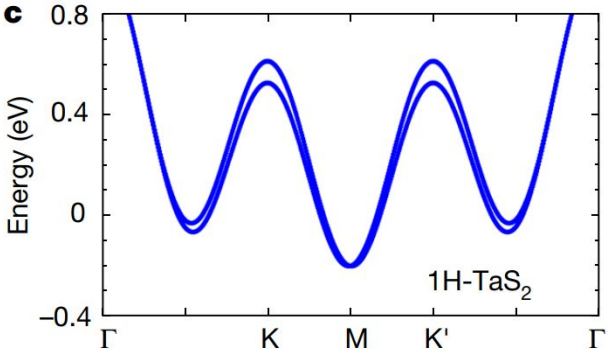




CDW state, localized magnetic supercell

1H-TaS2

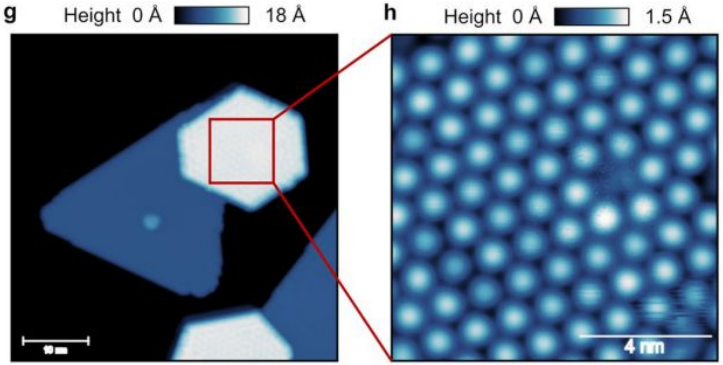


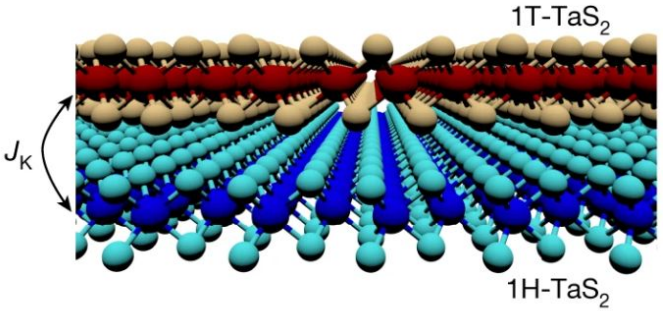


Metallic surface state

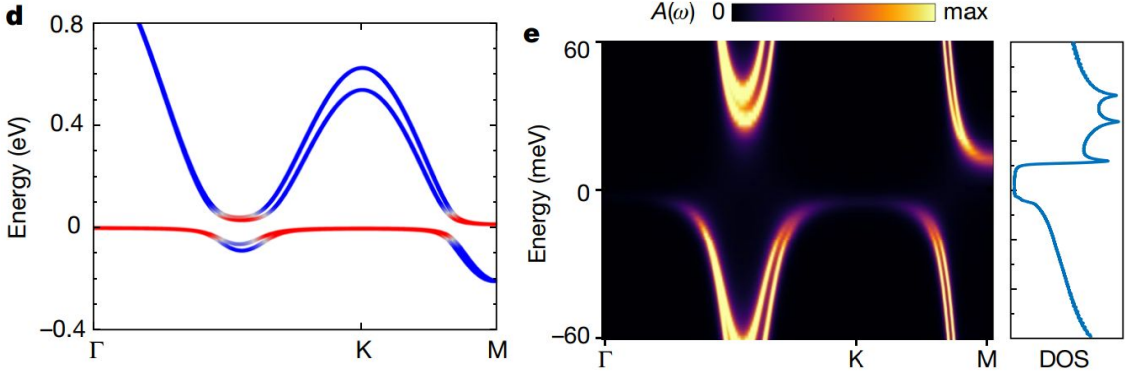
Material

1T-TaS2/ 1H-TaS2

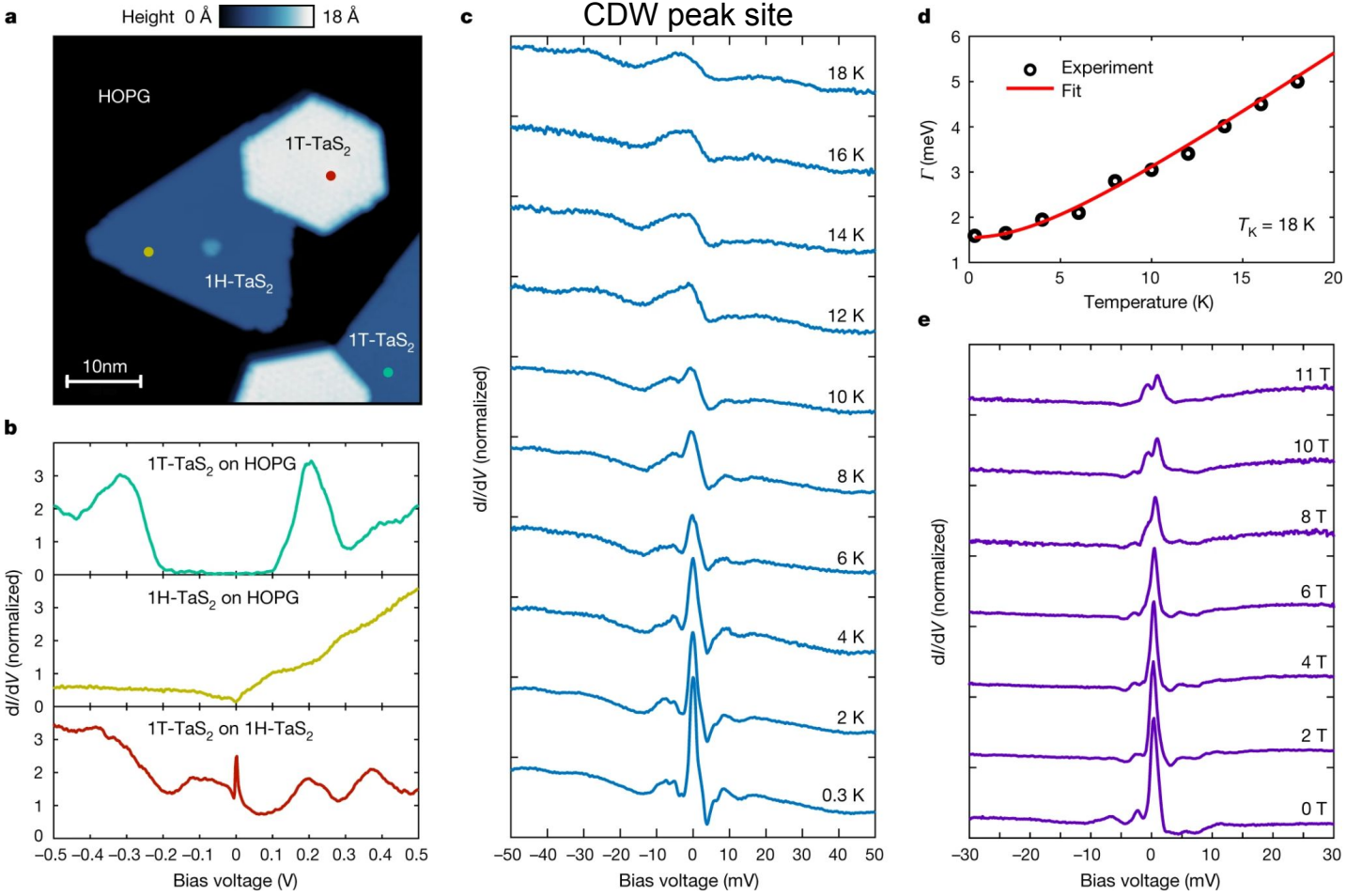




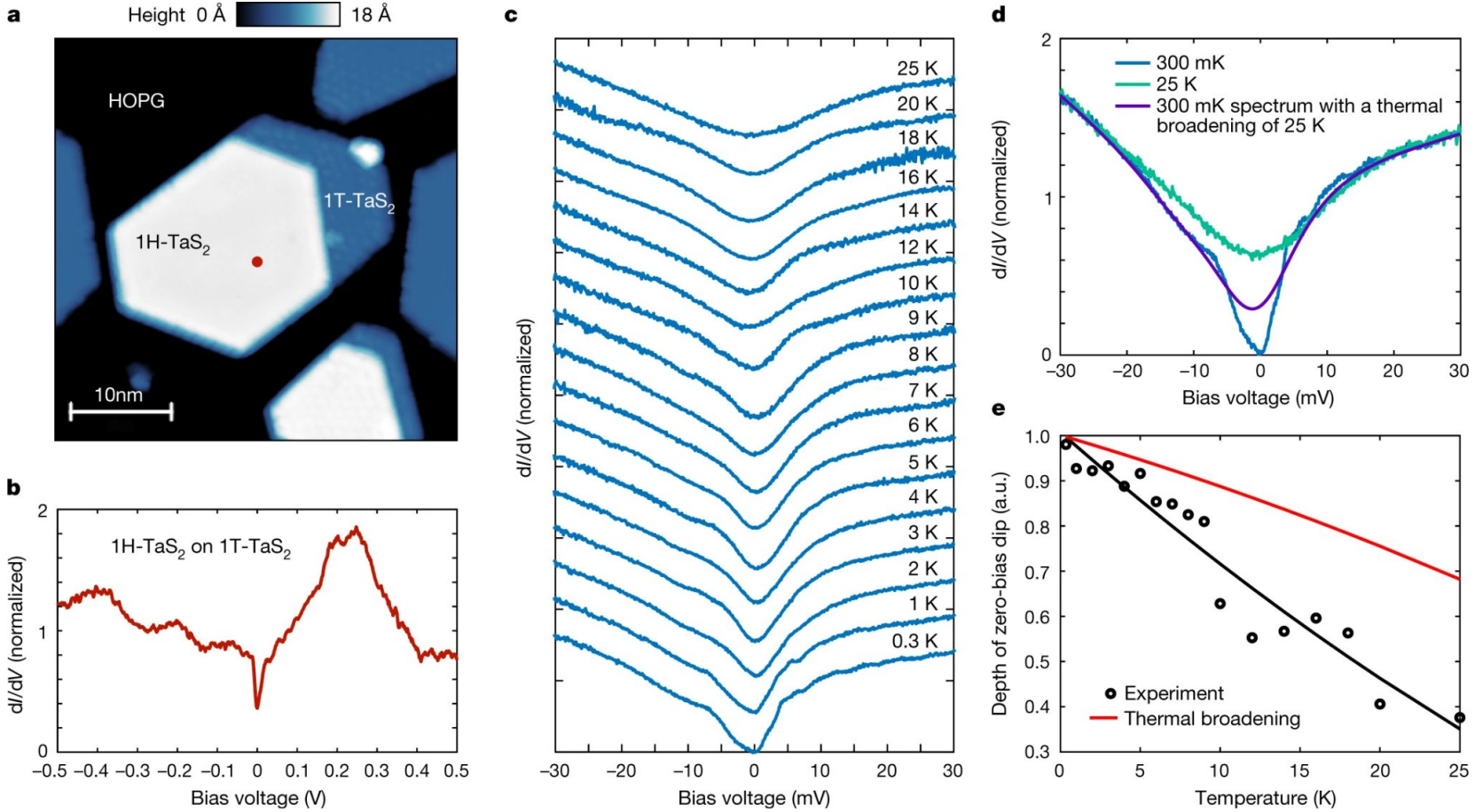
Inter-layer coupling between localized Kondo modes and conduction electrons creates hybridization gap.



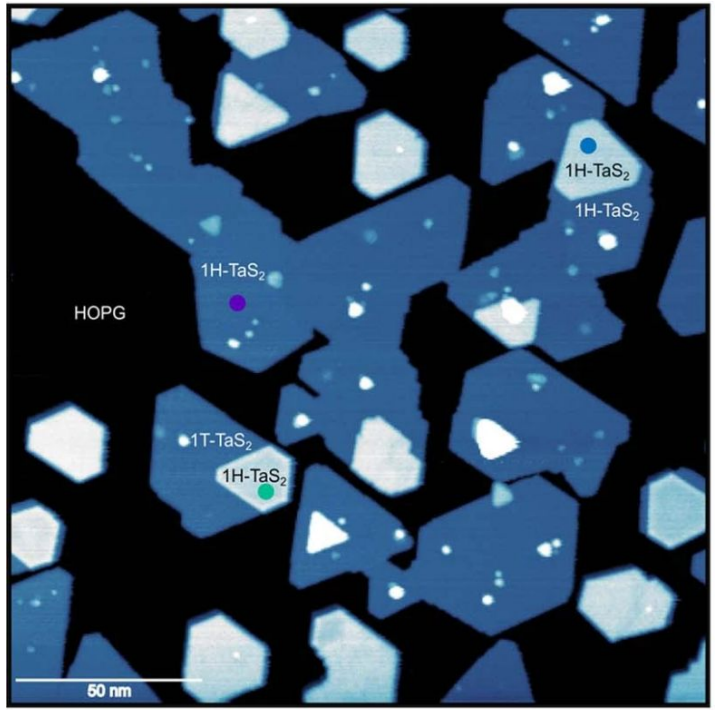
STM Spectroscopy

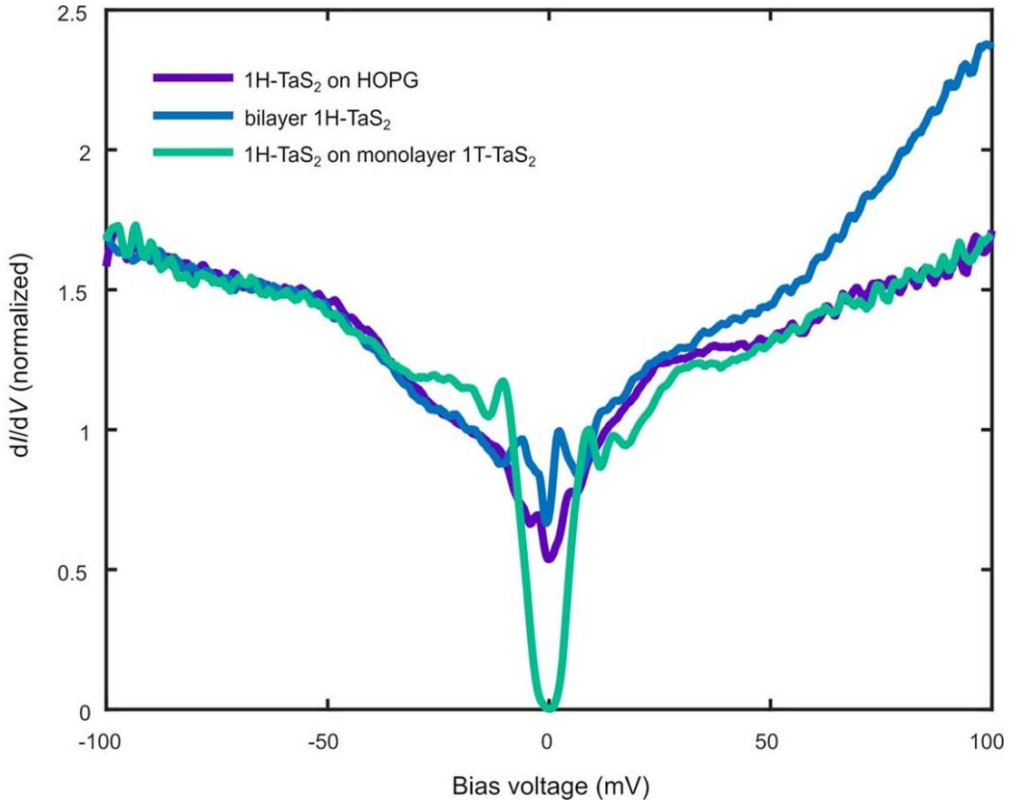


Heavy Fermion Hybridization Gap



Heavy Fermion Hybridization Gap





Conclusions

- Platform for tunable Kondo lattice physics in vdW heterostructures.
- Less defects than in traditional heavy fermion materials, potential to probe large scale areas with STM.
- Similarity to atom-manipulation Kondo Lattices from our group, potential for adatom-vdW hybrid structures.