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ARTICLES

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Correlated electronic phases in twisted bilayer transition metal dichalcogenides

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Article

Quantum criticality in twisted transition metal dichalcogenides

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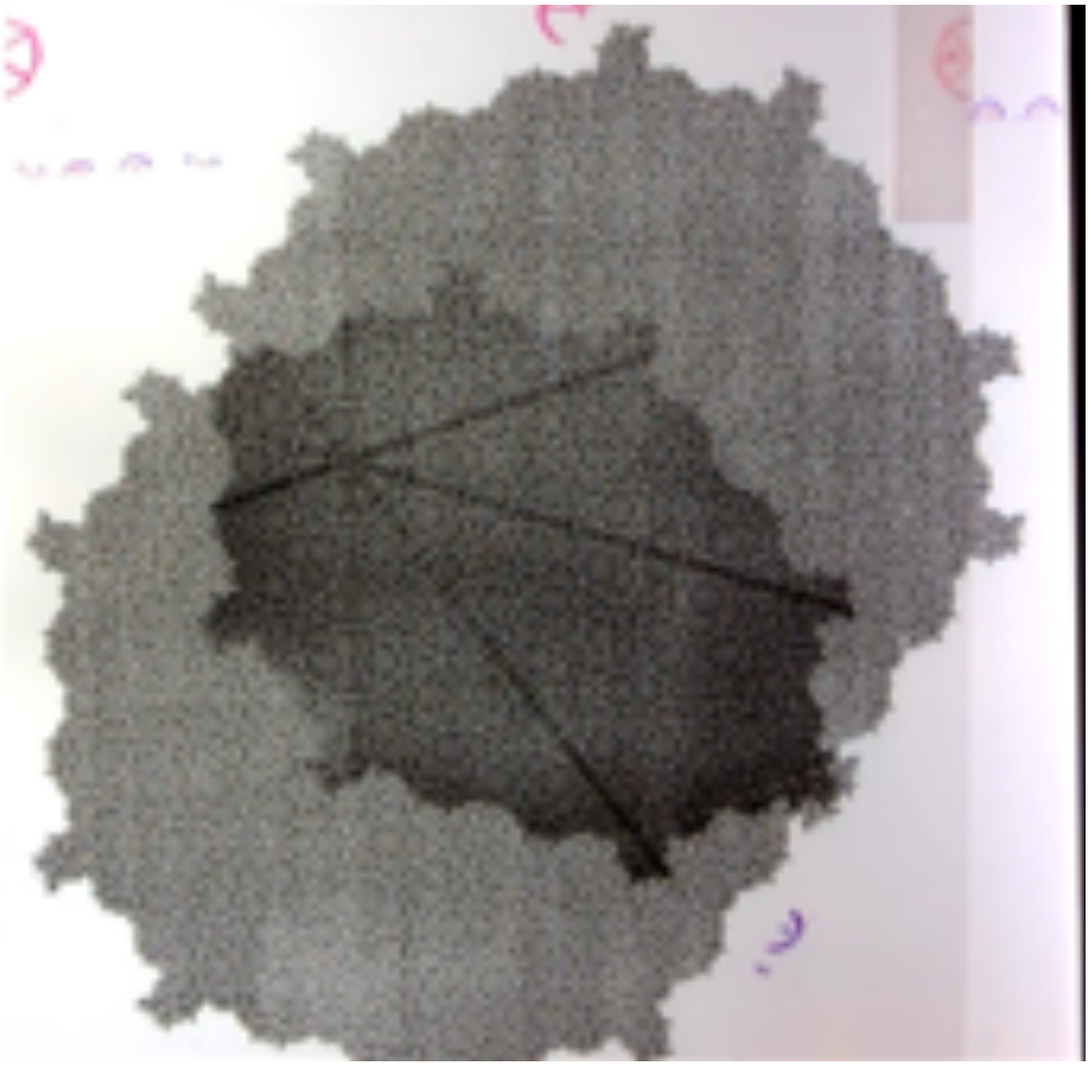
Gianmarco Gatti
DQMP - UniGe

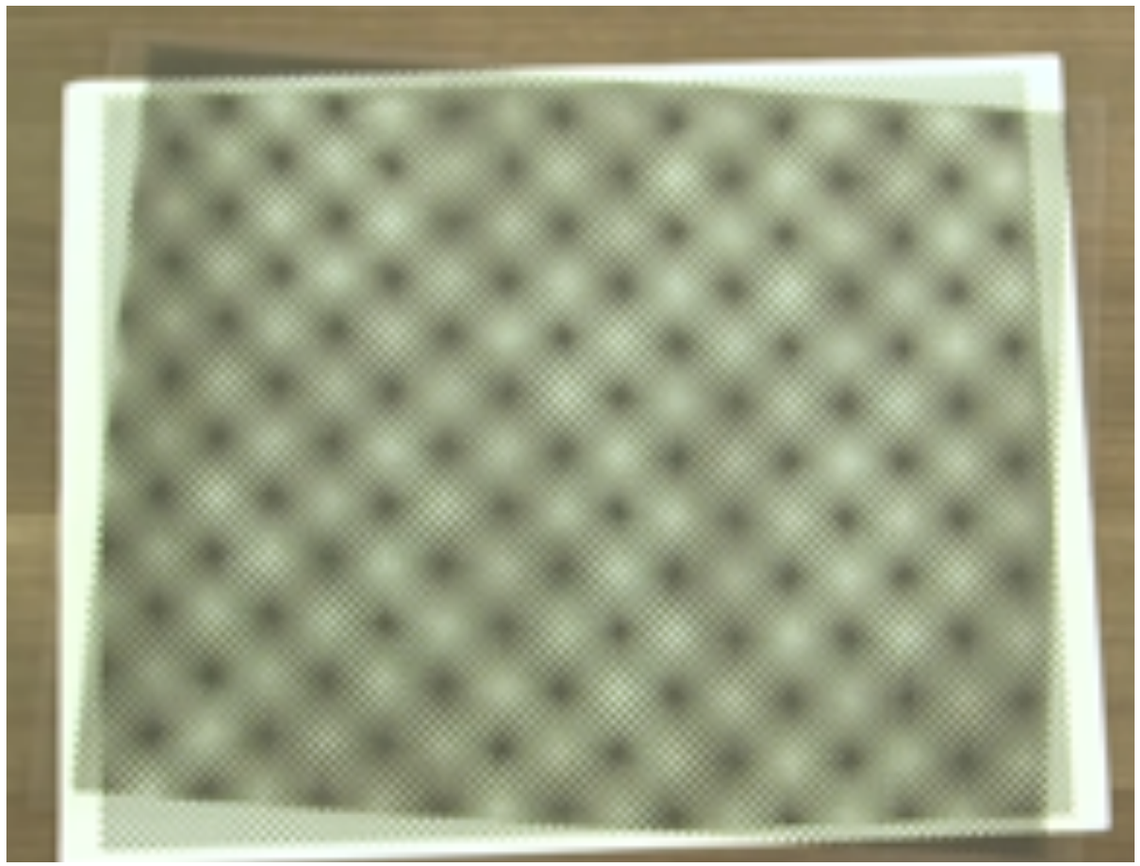
Geneva, 11th March 2022

UNIVERSITÉ DE GENÈVE

Moiré on the Internet

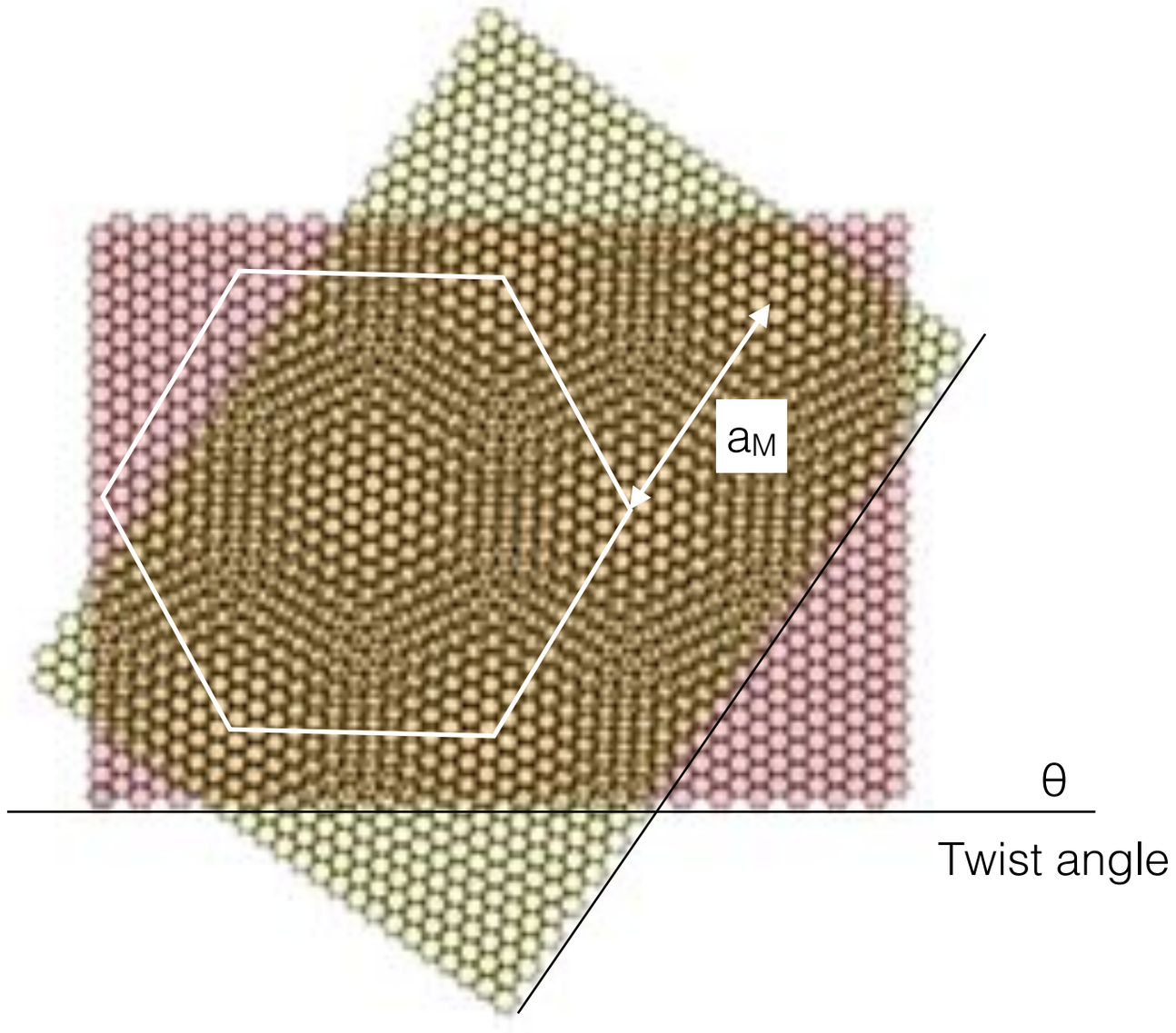


Roger Penrose



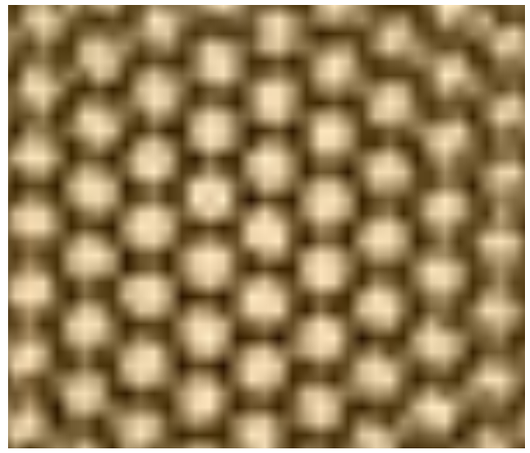
Numberphile youtube channel

Moiré in science

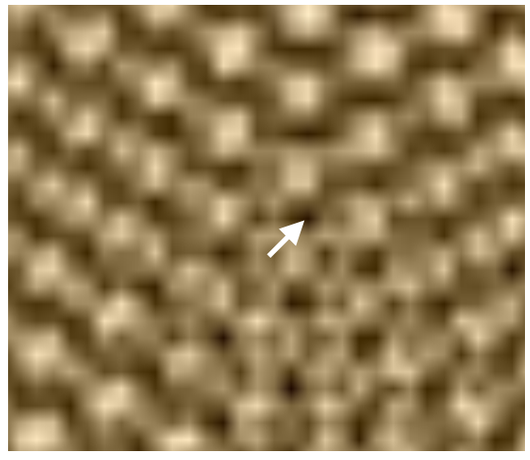


Hexagonal lattice

Stackings



AA



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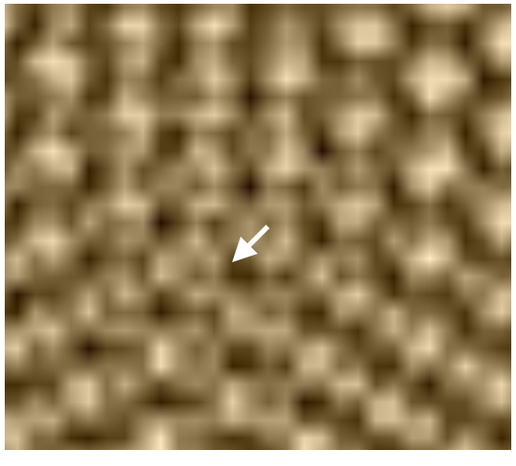
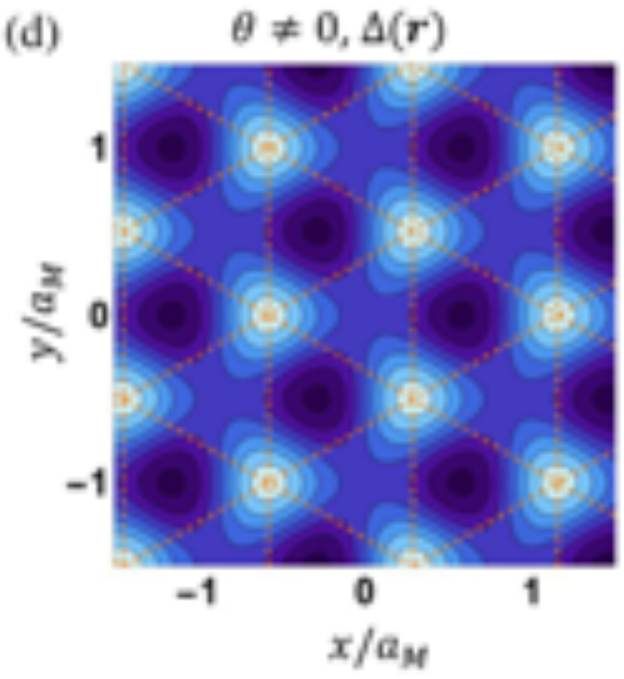
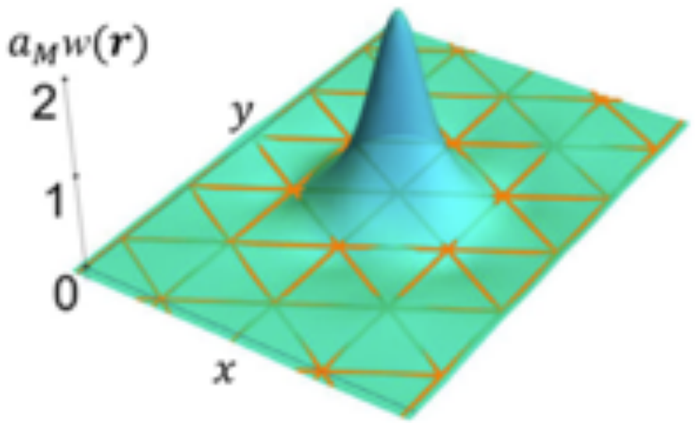


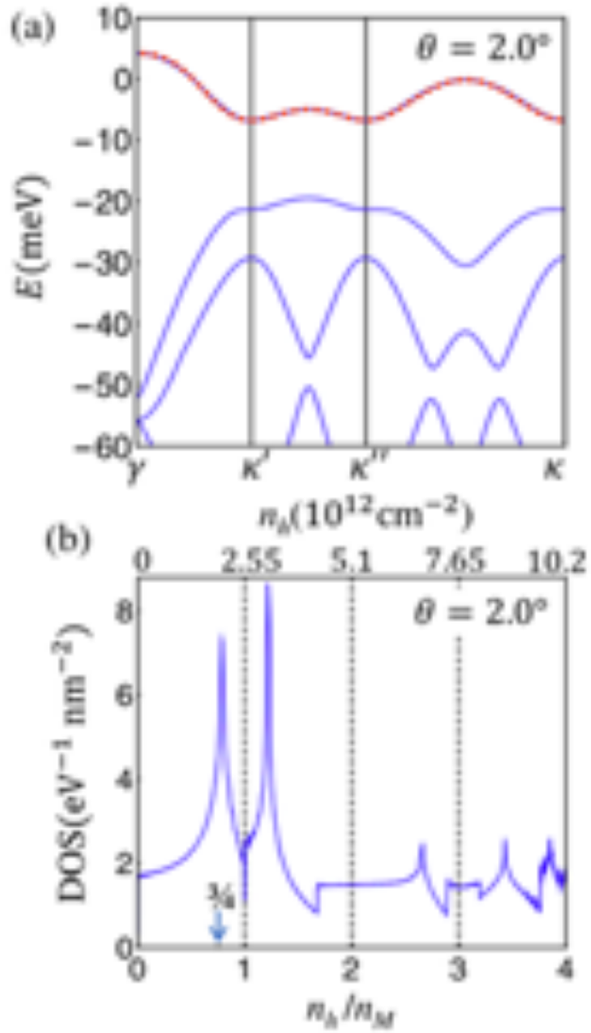
BA

Displacement vector

Twisted transition metal dichalcogenides







$$\Delta(\boldsymbol{r}) = \sum_{\boldsymbol{b}}{}' V(\boldsymbol{b}) \exp[i\boldsymbol{b}\cdot\boldsymbol{r}]$$

Moiré superpotential

$$a_W \approx [\hbar^2/(\beta m^* V)]^{1/4}\sqrt{a_M}$$

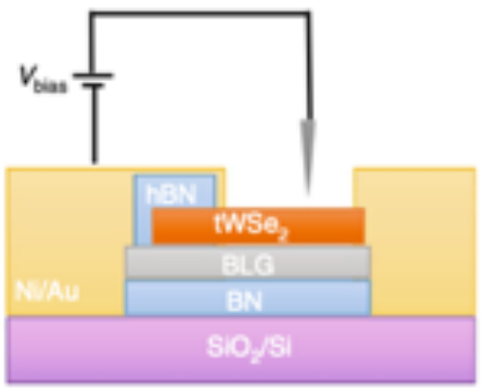
Wannier size

Bandwidth ≈ exp (a_W / a_M) ≈ exp (1 / $\sqrt{a_M}$)

Coulomb $U_0 \sim e^2/(\epsilon a_M)$

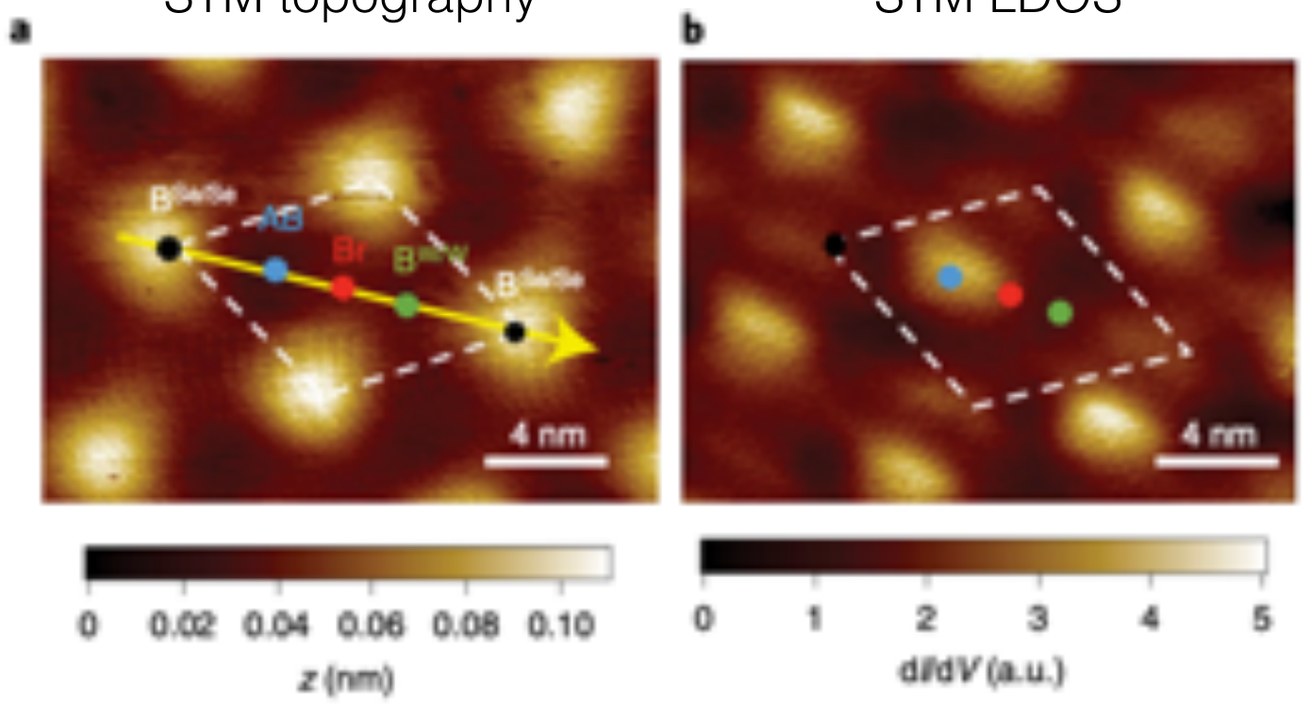
F. Wu, T. Lovorn, E. Tutuc, and A. H. MacDonald, Physical Review Letters 121, 026402 (2018).

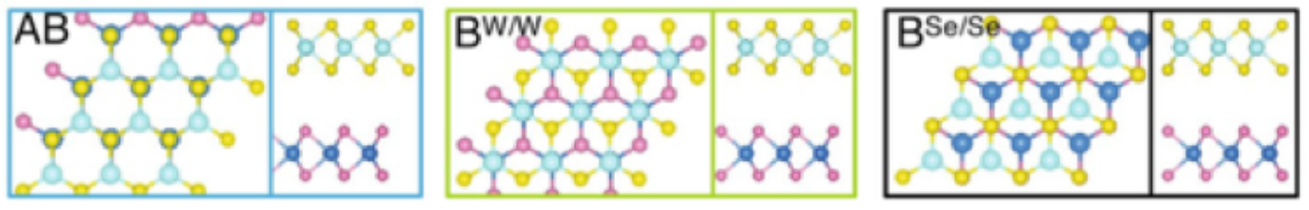
Twisted WSe_2 - STM



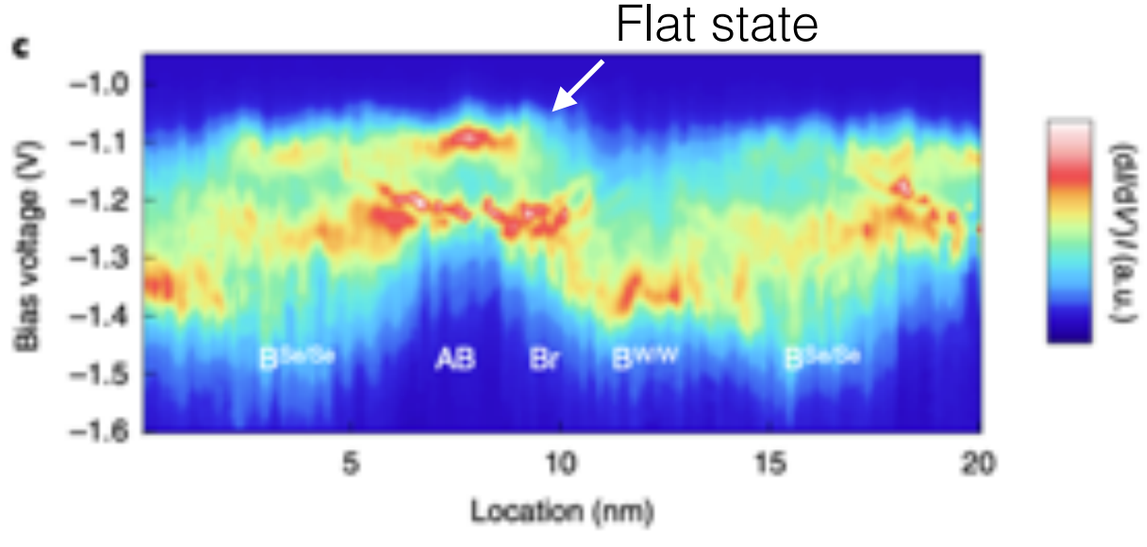
STM topography

STM LDOS



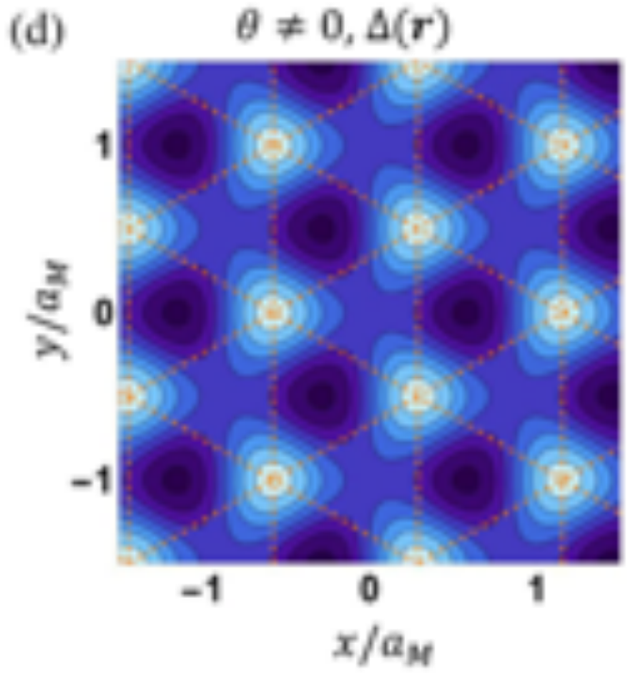


Flat state



Z. Zhang, et al.
Nat. Phys. 16, 1093–1096 (2020)

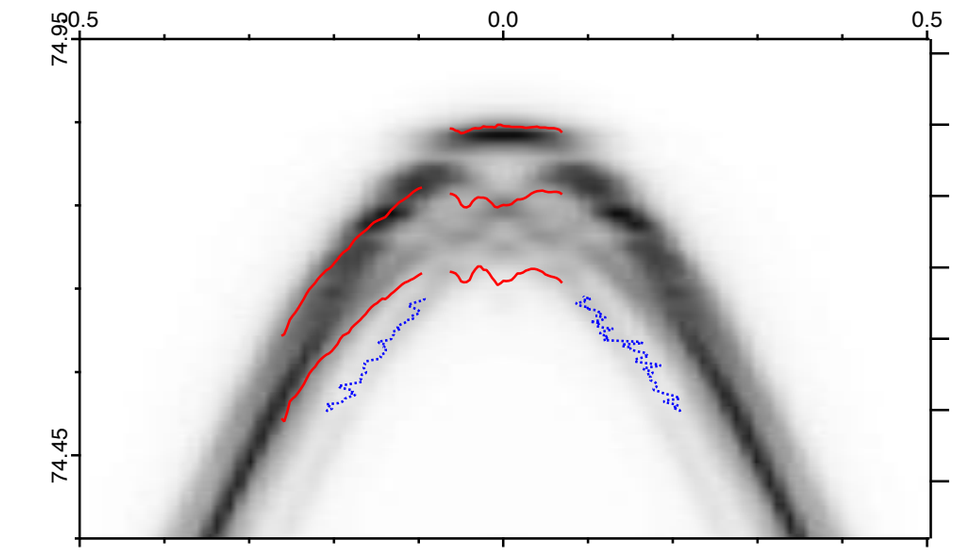
Twisted WSe_2 - ARPES

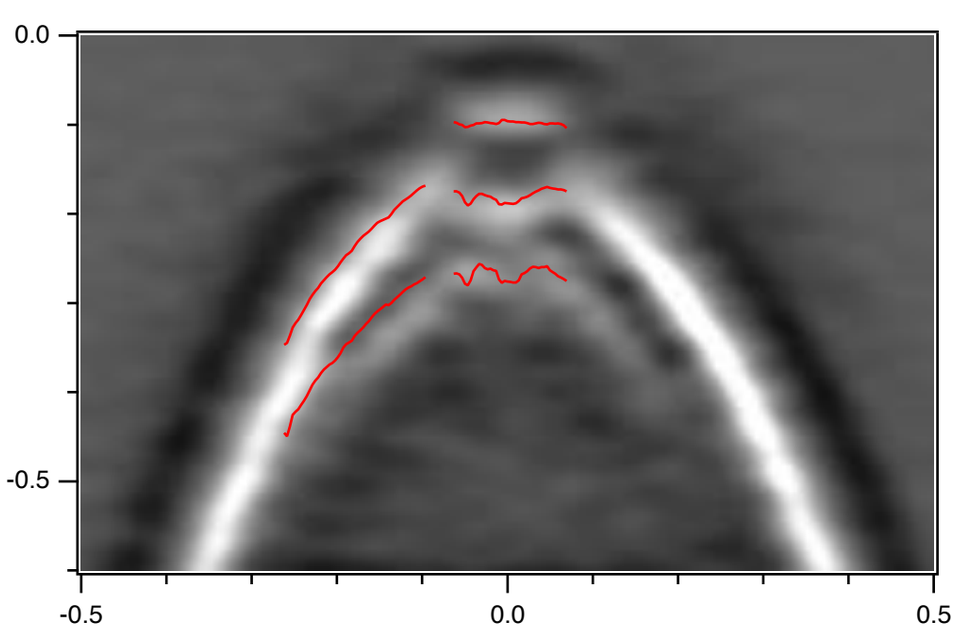


$$\Delta(\boldsymbol{r}) = \sum_{\boldsymbol{b}}^{\prime} V(\boldsymbol{b}) \exp[i\boldsymbol{b} \cdot \boldsymbol{r}]$$

Moiré superpotential

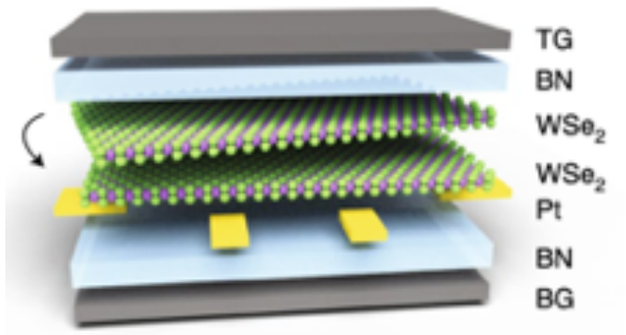
Continuum model

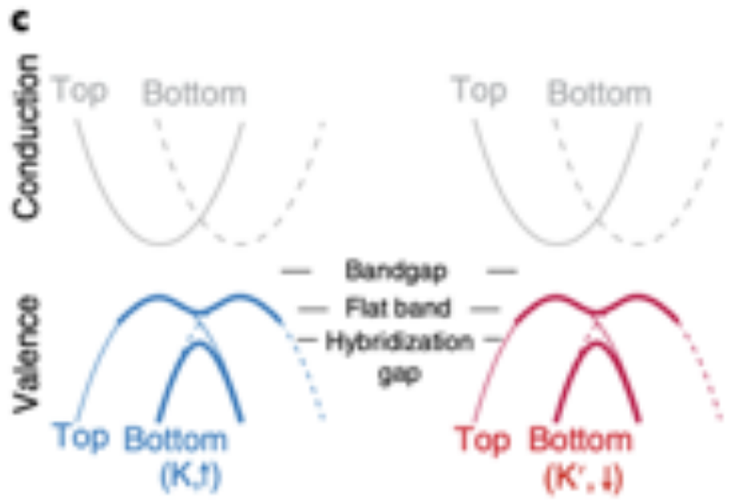


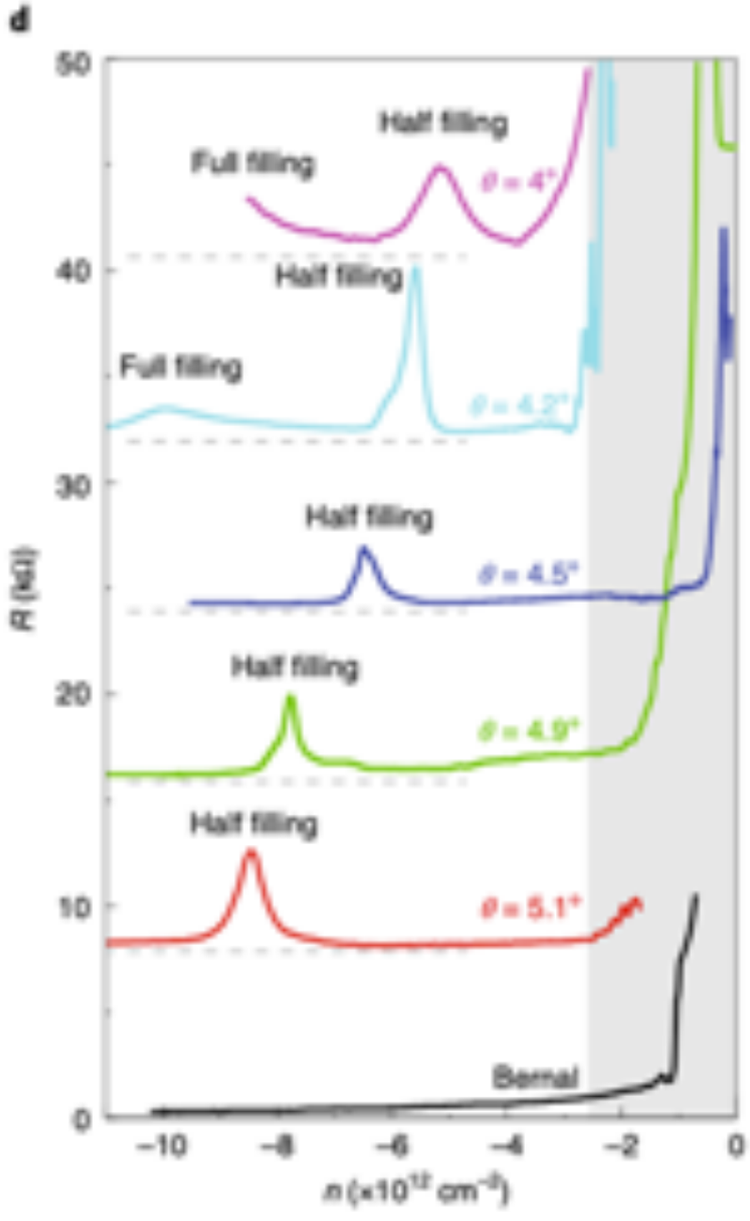


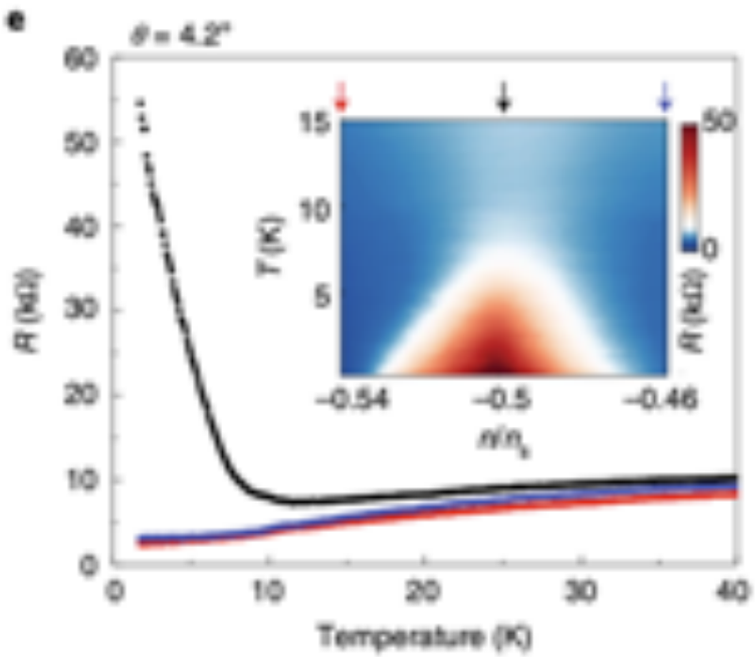
ARPES

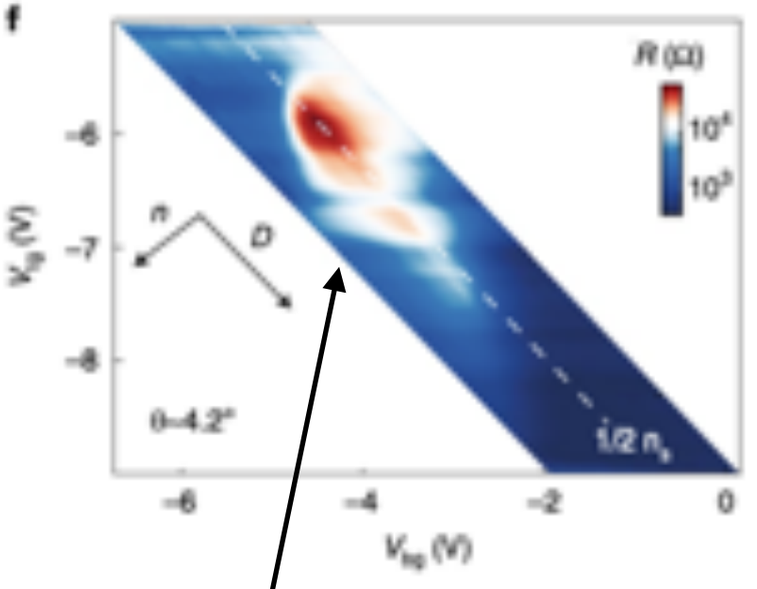
Gate-tuned transport on tWSe2







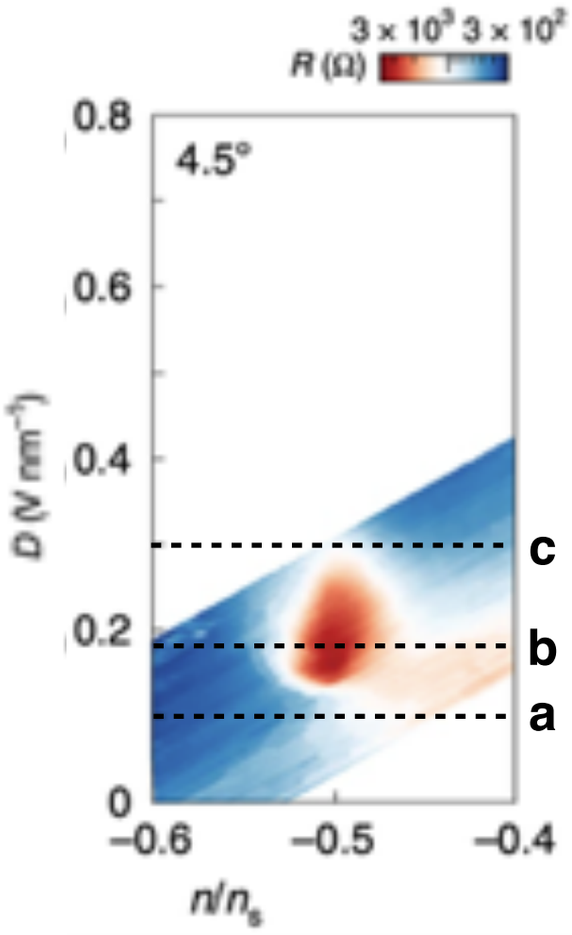


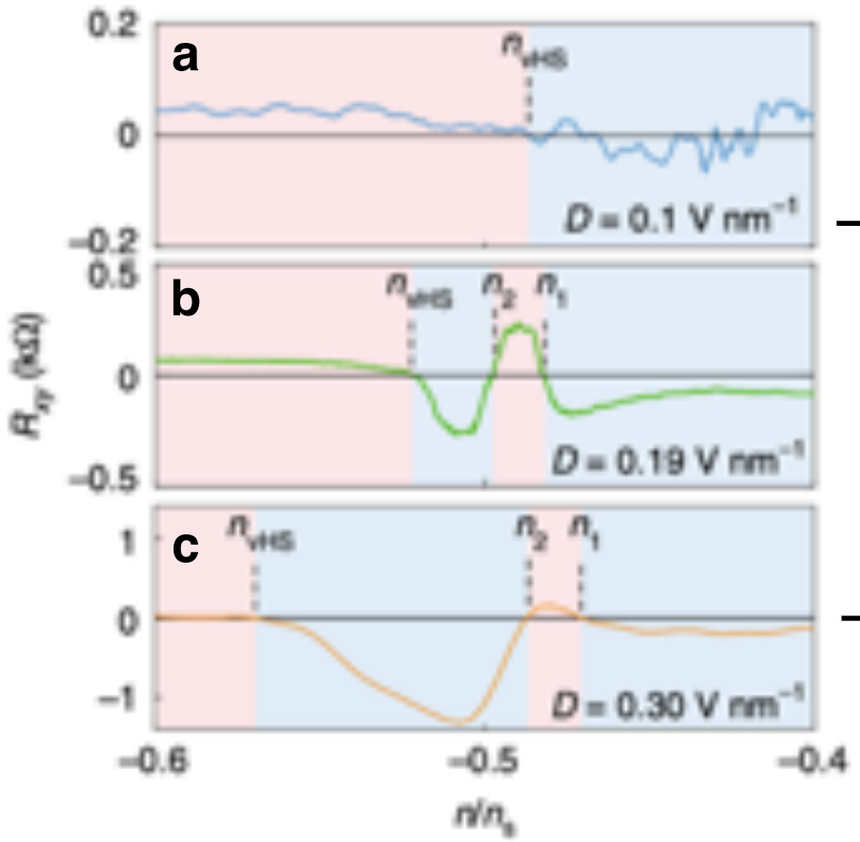


Metal-insulator transition

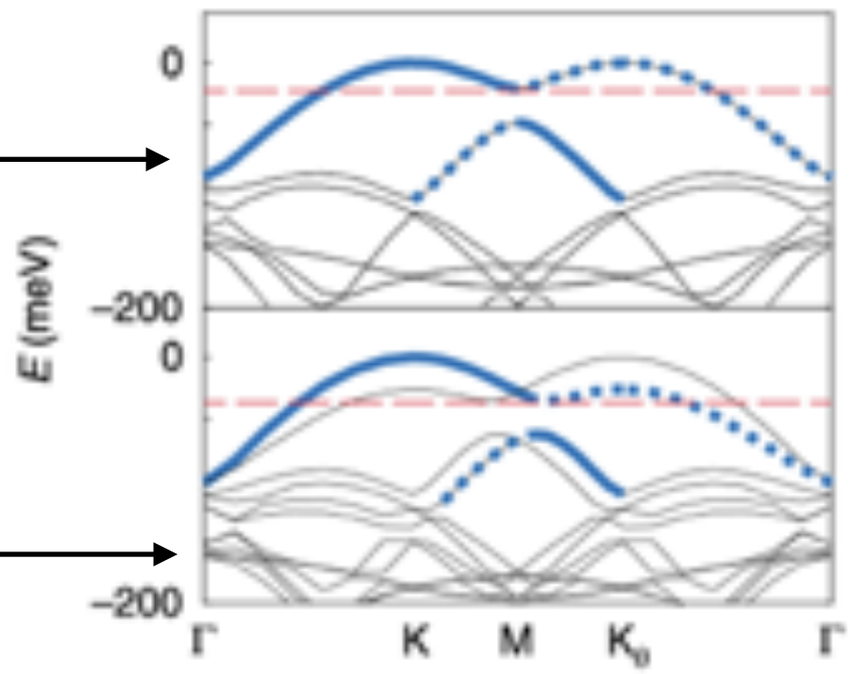
L. Wang, E.-M. Shih, A. Ghiotto, et al. Nat. Mater. 19, 861–866 (2020)

Nature of the insulating state



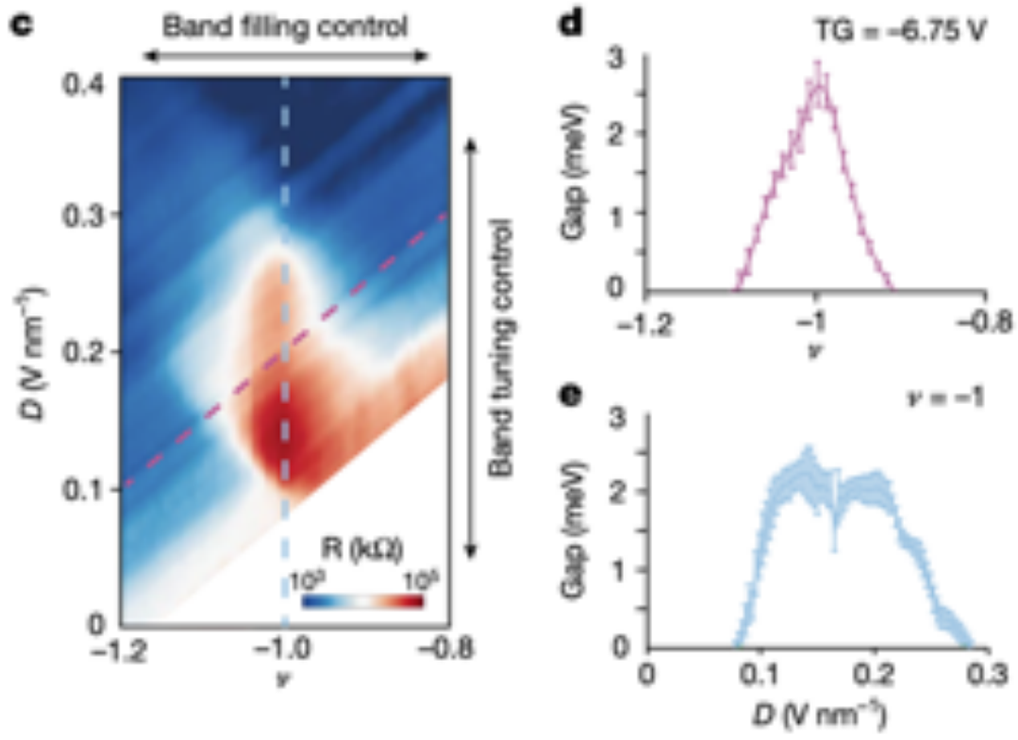


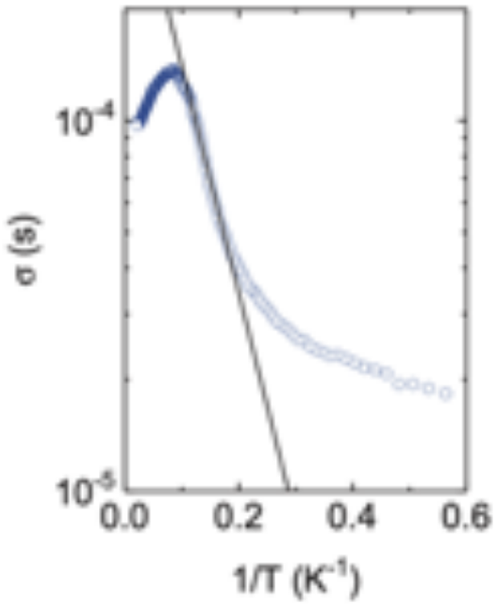
Hall resistance

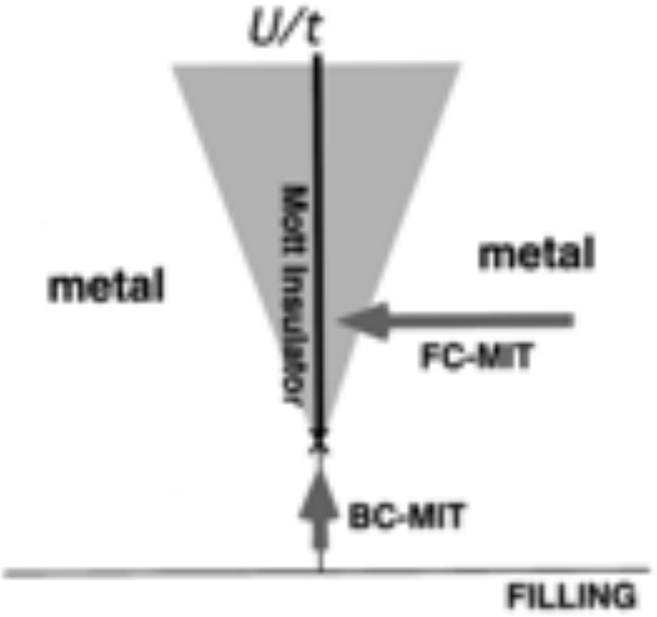


DFT calculations

Continuous metal-insulator transition



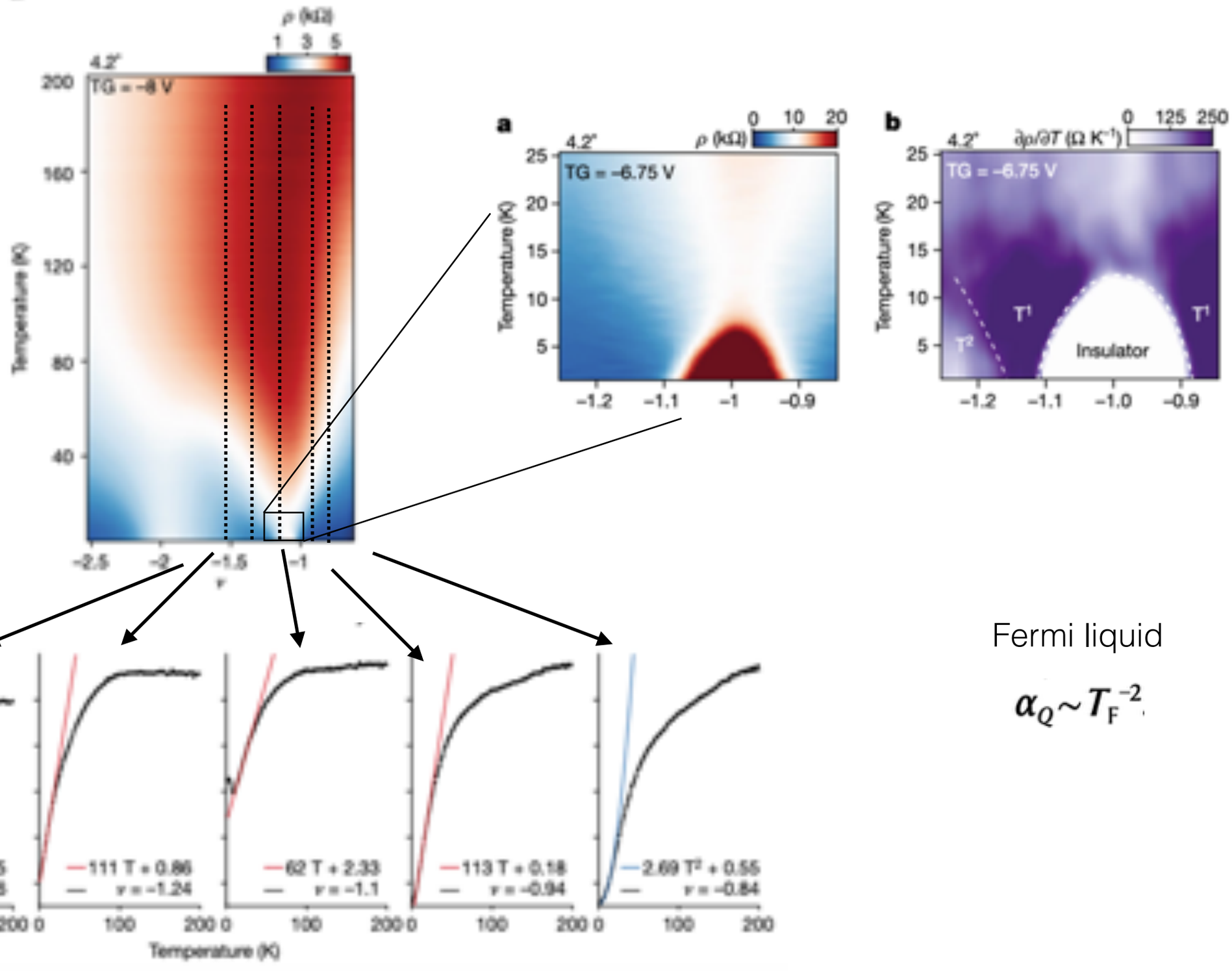




Hubbard picture

A. Ghiotto, E.-M. Shih, et al. Nature 597, 345–349 (2021).

Strange metal phase



Fermi liquid

$$\alpha_Q \sim T_F^{-2}$$

$$\rho(T) = \alpha_Q T^2 + \rho_0$$

T- squared resistivity

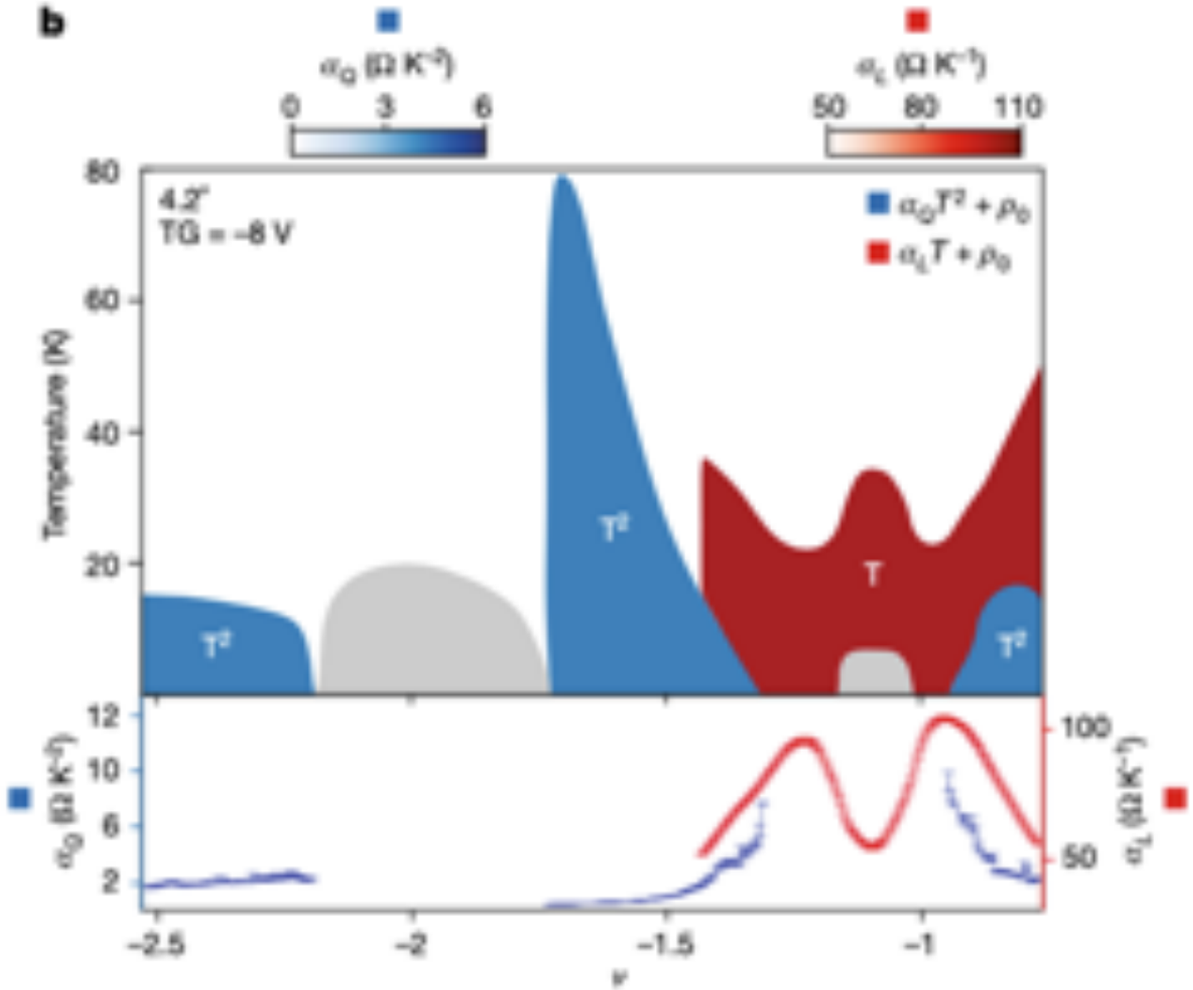
$$\rho(T) = \alpha_L T + \rho_0$$

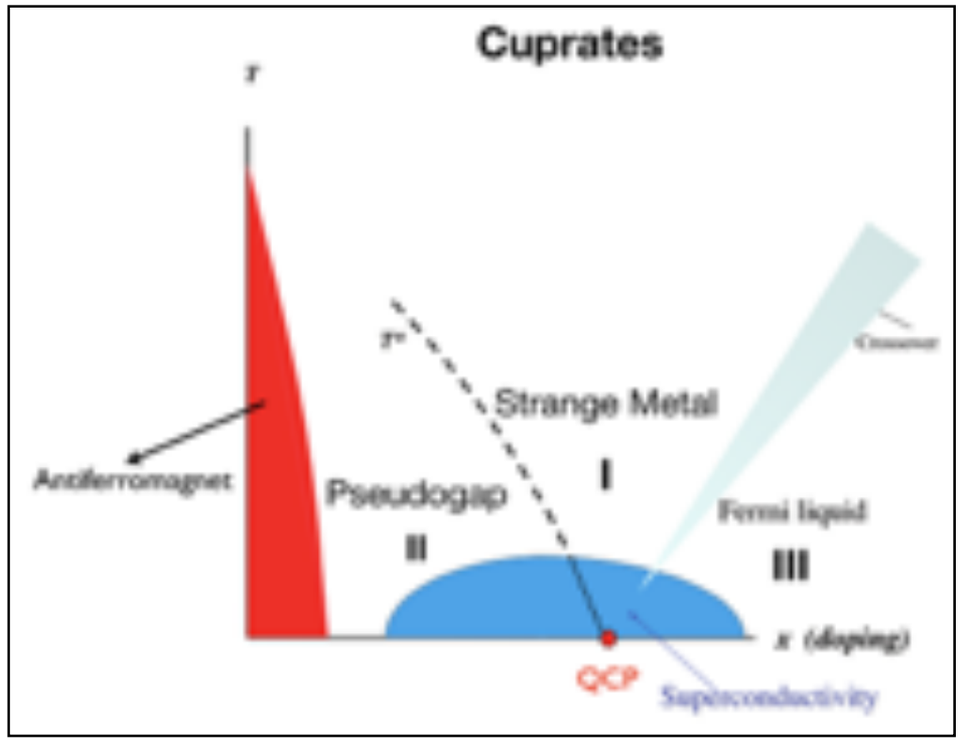
T- linear resistivity

$$\rho(T) = \alpha_Q T^2 + \rho_0$$

T- squared resistivity

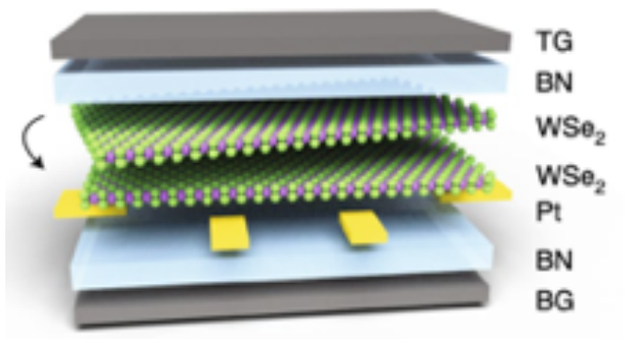
Strange metal phase





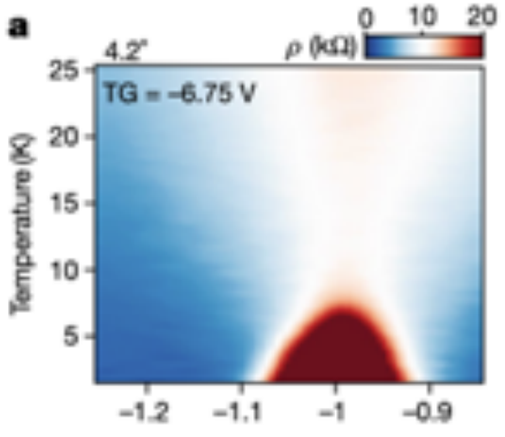
C. WARMA, REVIEWS OF MODERN PHYSICS, VOLUME 92, JULY–SEPTEMBER 2020

Conclusions



- Moderate electronic correlations drive the insulating phase in $tWSe_2$

- The insulating phase at half-filling seems to be described effectively by a Hubbard model: spin-liquid?



- The metal-insulator transition is continuous in carrier doping and displacement field and driven by quantum fluctuations