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## Interlayer stacking controls the electronic properties of the van der Waals material 1T-TaS<sub>2</sub>

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Given the small binding between layers, stacking of van der Waals materials is a powerful tool for exploring the physics of quantum condensed matter. However, exploitation for engineering will require taking advantage of thicker defective stacks, or an ability to control the stacking order via external stimuli, such as electrical or optical pulses.

I will present X-ray diffraction data of the equilibrium [1] and non-equilibrium [2] charge-density wave phases of the model material 1T-TaS<sub>2</sub>, promising application as a highly efficient cryogenic phase-change memory platform. Comparison to a computational framework based on recursive Hendricks-Teller calculations and Monte Carlo simulations [3] reveals that layer stacking order and faults underly the rich electronic phase diagram of 1T-TaS<sub>2</sub>. The experiments also identify charge rearrangement and concomitant lattice strain as the drivers of the metastable hidden phase transition. More generally, the results underscore the importance of domain sizes and layer stacking in defining electronic behaviors of van der Waals materials.

[1] C. Burri, H. G. Bell, F. Dizdarević, W. Hu, J. Ravnik, J. Vonka, Y. Ekinci, S.-W. Huang, S. Gerber & N. Hua. Three-dimensional electronic domain correlations in 1T-TaS<sub>2</sub>. arXiv:2508.17839.

[2] C. Burri, N. Hua, D. Ferreira Sanchez, W. Hu, H. G. Bell, R. Venturini, S.-W. Huang, A. G. McConnell, F. Dizdarević, A. Mraz, D. Svetin, B. Lipovšek, M. Topič, D. Kazazis, G. Aeppli, D. Grolimund, Y. Ekinci, D. Mihailović & S. Gerber. Imaging of electrically controlled van der Waals layer stacking in 1T-TaS<sub>2</sub>. arXiv:2411.04830 (Nat. Commun., accepted).

[3] N. Hua, F. Petocchi, H. G. Bell, G. Aeppli, P. Werner & S. Gerber. Interlayer stacking controls the electronic properties of the van der Waals material 1T-TaS<sub>2</sub>. arXiv:2503.24124 (Phys. Rev. Research, accepted).

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