# Phonon-Driven Pathway to the 1*T*-$TaS_2$ Hidden State

Nelson Hua,[1,2] Xun Jia,[3] Corinna Burri,[1,4] H.G. Bell,[1,4] Swan Htun,[3] Faris Dizdarević,[1,4] Maël Clémence,[1,4] Aidan G. McConnell,[1,4] Wenxiang Hu,[1,4] Adrian Rutschmann,[1,4] Travis Frazer,[3] Jan Ravnik,[1] Vincent Esposito,[5] Matthias Hoffmann,[5] Takahiro Sato,[5] Diling Zhu,[5] Hasan Yavas,[5] Serhane Zerdane,[1] Shih-Wen Huang,[1] Roman Mankowsky,[1] Mathias Sander,[1] Ian K. Robinson,[6,7] Dragan Mihailović,[8] Yue Cao,[3] and Simon Gerber[1]

[1] *PSI Center for Photon Science, Paul Scherrer Institute, 5232 Villigen-PSI, Switzerland*
[2] *Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland*
[3] *Materials Science Division, Argonne National Laboratory, Lemont, Illinois 60439, USA*
[4] *Laboratory for Solid State Physics and Quantum Center, ETH Zurich, Zurich, Switzerland*
[5] *Linac Coherent Light Source, SLAC National Accelerator Laboratory, Menlo Park, California 94025, USA*
[6] *Condensed Matter Physics and Materials Science Division, Brookhaven National Laboratory, Upton, NY, USA*
[7] *London Centre for Nanotechnology, University College London, London, UK*
[8] *Department of Complex Matter, Institut Jožef Stefan, Ljubljana, Slovenia*

Among the layered transition-metal dichalcogenides, 1*T*-$TaS_2$ uniquely exhibits a hidden, metallic charge density wave phase. A myriad of experiments have demonstrated the ability to use an optical or electrical excitation to access this metastable state [2,3], but ultimately the non-thermal mechanism that unlocks this hidden phase has eluded observations. Here we used time-resolved X-ray diffraction with three-dimensional reciprocal space resolution to reveal the coherently driven dynamics tied to both the commensurate and hidden charge density wave states. Supported by dynamic structure factor simulations [3] and unsupervised machine learning, our results show that an out-of-plane $A_g$ phonon mode in the commensurate state facilitates a dismantling of dimers and a subsequent interlayer restacking to the hidden state. Furthermore, progressive bulk switching and a transient interlayer melting of the hidden phase underscores the significance that stacking dynamics play in an otherwise strongly correlated two-dimensional material.

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