Coexistence of interacting charge density waves in a layered semiconductor

(Oral)

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Coexisting orders are key features of strongly correlated materials and underlie many intriguing phenomena from unconventional superconductivity to topological orders. Here, we report the coexistence of two interacting charge-density-wave (CDW) orders in $EuTe_4$, a layered crystal that has drawn considerable attention owing to its anomalous thermal hysteresis and a semiconducting CDW state despite the absence of perfect Fermi surface nesting [1,2]. By accessing unoccupied conduction bands with time- and angle-resolved photoemission measurements, we find that mono- and bi-layers of Te in the unit cell host different CDWs that are associated with distinct energy gaps [3]. The two gaps display dichotomous evolutions following photoexcitation, where the larger bilayer CDW gap exhibits less renormalization and faster recovery. Surprisingly, the CDW in the Te monolayer displays an additional momentum-dependent gap renormalization that cannot be captured by density-functional theory calculations. This phenomenon is attributed to interlayer interactions between the two CDW orders, which account for the semiconducting nature of the equilibrium state. Our findings not only o er microscopic insights into the correlated ground state of EuTe4 but also provide a general non-equilibrium approach to understand coexisting, layer-dependent orders in a complex system.

1. D. Wu, *et al.*, Phys. Rev. Mater. 3, 024002 (2019).
2. B. Q. Lv*, Alfred Zong*, *et al.,* Phys. Rev. Lett. 128, 036401 (2022)
3. B. Q. Lv*, Alfred Zong*, *et al.,* Phys. Rev. Lett. 132, 206401 (2024).