

Controlling Charge Density-Wave States in Single-Layer Transition-Metal Dichalcogenides

Philip King

Control over materials thickness down to the single-atom scale has emerged as a powerful tuning parameter for manipulating not only the single-particle band structures of solids, but increasingly also their interacting electronic states and phases. A particularly attractive materials system in which to explore this is the transition-metal dichalcogenides, both because of their naturally-layered van der Waals structures as well as the wide variety of materials properties which they are known to host. Yet, how their interacting electronic states and phases evolve when thinned to the single-layer limit remains a key open question in many such systems. Here, we use angle-resolved photoemission to investigate the electronic structure and charge density wave (CDW) phases of monolayer TiSe_2 , TiTe_2 , and VSe_2 epitaxial thin films grown by molecular-beam epitaxy [1]. Three-dimensionality is a core feature of the electronic structure of all of these parent compounds, but we show how their CDW phases not only persist, but are strengthened, in the monolayer limit. In TiSe_2 , we observe a strong-coupling and orbital-selective CDW [2], necessarily without a k_z -selectivity in band hybridisation that is of key importance for the bulk instability [3], while TiTe_2 is driven into a charge-ordered phase in the monolayer which is not stable in the bulk at all. In VSe_2 , we show how the monolayer hosts a much stronger-coupling CDW instability than for the bulk compound, which in turn drives a metal-insulator transition, removing a competing instability to ferromagnetism [4]. We show how ferromagnetism can, however, be re-established via proximity coupling [5]. Together, these studies point to the delicate balance that can be realized between competing interacting states and phases in monolayer transition-metal dichalcogenides, and suggest new strategies for controlling these.

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[5] Vinai *et al.*, Phys. Rev. B 101, 035404 (2020).