Tunable many-body interactions in bulk and edge of the 2D topological excitonic insulator WTe_2

Bent Weber[1*]

[1] School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore, 21 Nanyang Link, 637371 Singapore

[*]e-mail: b.weber@ntu.edu.sg

Coulomb interactions among electrons and holes in 2D semimetals with overlapping valence and conduction bands at the Fermi level can give rise to a correlated insulating ground state via exciton formation and condensation – an *excitonic insulator*. A material platform in which such excitonic insulating state uniquely combines with non-trivial band topology is tungsten ditelluride (WTe_2) [1-4], in which a *2D topological excitonic insulator* (2D TEI) forms.

From scanning probe spectroscopy down to 4.2K [3], we demonstrate that the 2D TEI state in WTe_2 is susceptible to a gate-tunable quantum phase transition – evident from an abrupt collapse of its 2D bulk energy gap upon ambipolar field-effect doping. Impossible to explain from a single-particle picture, the quantum phase transition provides direct evidence of the strong excitonic-type Coulomb interactions in the WTe_2 2D bulk, stabilizing the topological gap at low doping. Clear signatures of 1D topological boundary mode can be shown to prevail across the phase transition, harbouring a tunable helical Tomonaga-Luttinger Liquid (TLL) in the strongly coupling limit [4].

Field-effect tunability of a 2D Topological Excitonic Insulator (TEI) into either *n*- and *p*-type semimetals may promise novel handles of control over non-trivial 2D superconductivity with excitonic pairing.

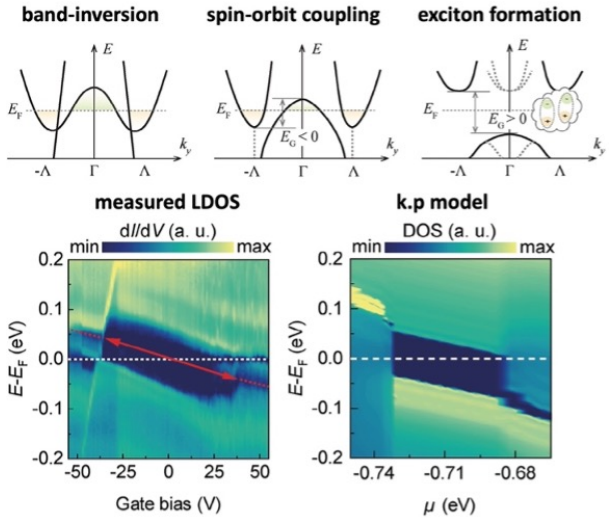

Fig. 1: Exciton formation and quantum phase transition in a topological excitonic insulator [3].

[1] M.S. Lodge, …, and B. Weber, Adv. Mat. 33, 2008029 (2021).
[2] B. Weber *et al*., J. Phys. Materials (2023)
[3] Y. Que, …, and B. Weber, Adv. Mat. 2309356 (2023)
[4] J. Jia, …, and B. Weber, Nature Comms. **13**, 6046 (2022)