nature physics

LETTERS

PUBLISHED ONLINE: 10 APRIL 2017 | DOI: 10.1038/NPHYS4091

Edge conduction in monolayer WTe_2

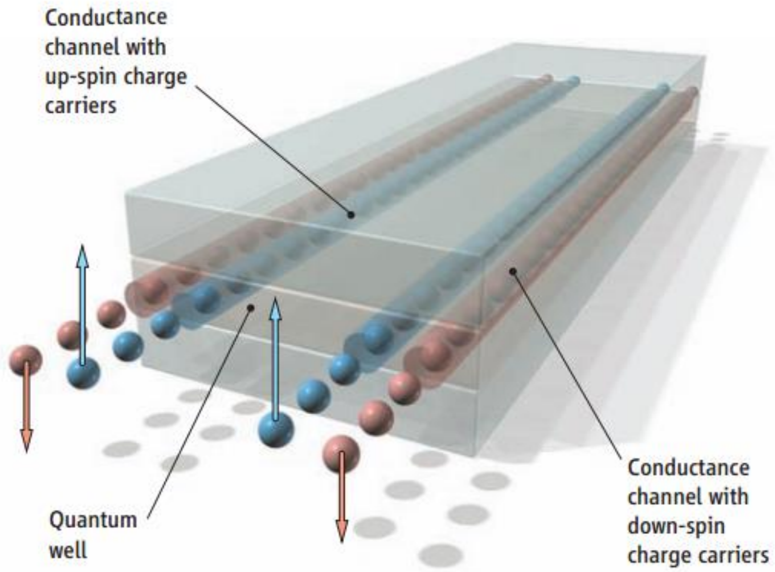
Zaiyao Fei[1], Tauno Palomaki[1], Sanfeng Wu[1], Wenjin Zhao[1], Xinghan Cai[1], Bosong Sun[1], Paul Nguyen[1], Joseph Finney[1], Xiaodong Xu[1,2*] and David H. Cobden[1*]

Outline

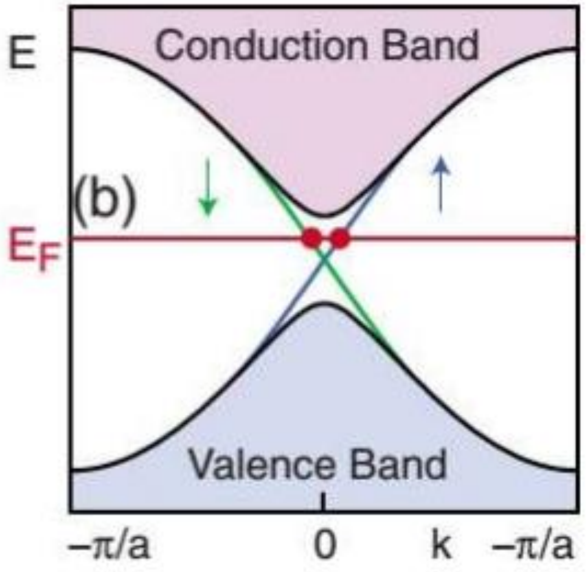
- Background
- Experimental results & explanations
- Summary

Background

Quantum spin Hall effect and 2DTI



Schematic of the spin-polarized edge channels in a quantum spin Hall insulator in a quantum well.



Band structure of 2DTI

◦ Background

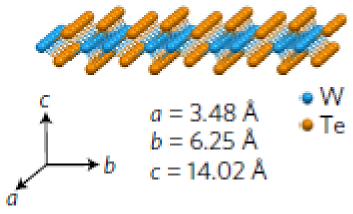
Some puzzles in experimental works on 2DTI of quantum wells

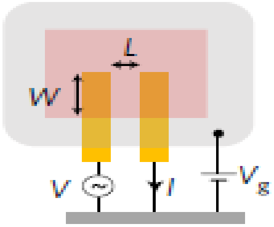
- The conductance at low temperatures is not perfectly quantized, becoming small in long edges
- The edge conductance showing mesoscopic fluctuations as a function of gate voltage.
- The edges show signs of conducting even at high magnetic field.
- Non-helical edge conduction may also be present, due for instance to band bending when a gate voltage is applied in the quantum wells.

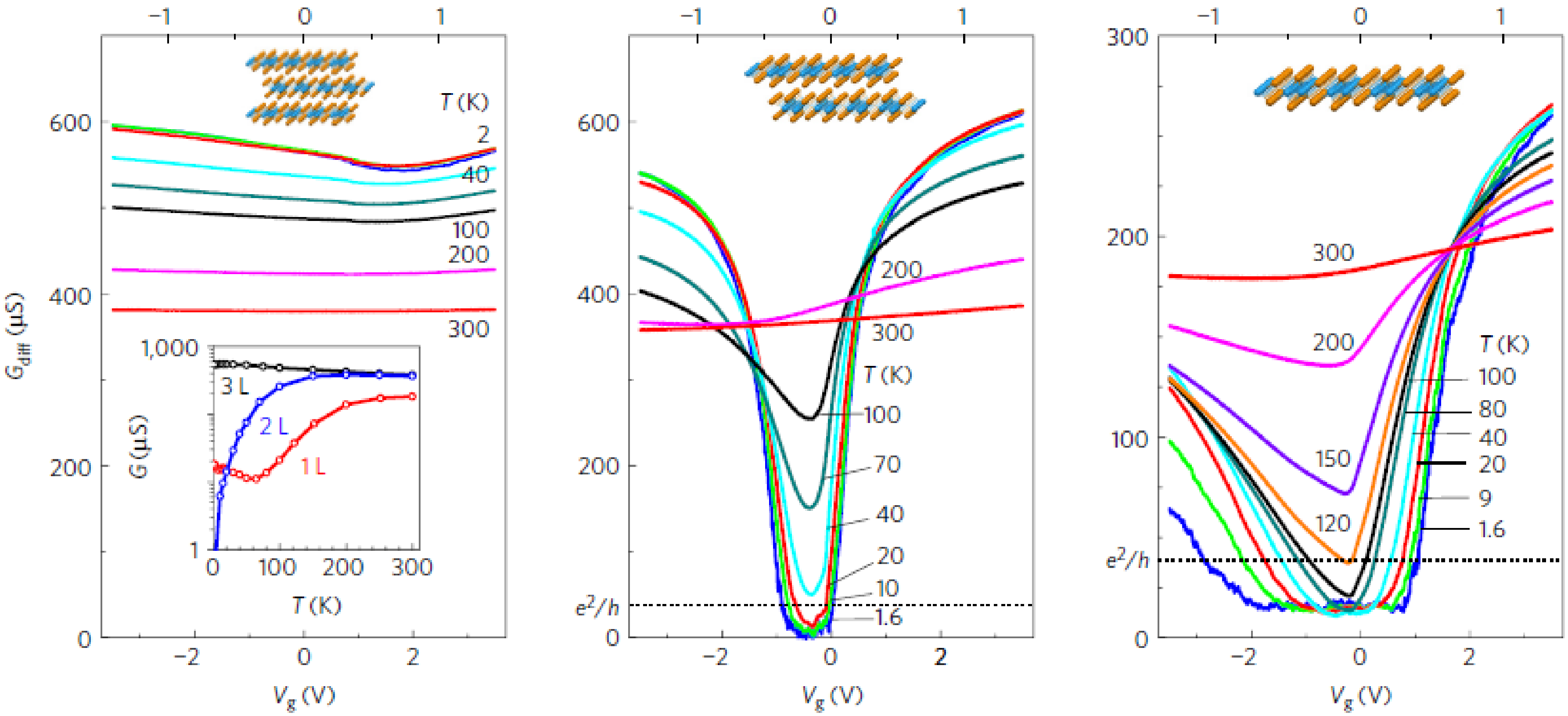
So, identification of a natural monolayer 2DTI would be helpful for elucidating and exploiting TI physics

• Experimental results & explanations

Temperature dependence of G_{diff} in different thickness WTe_2

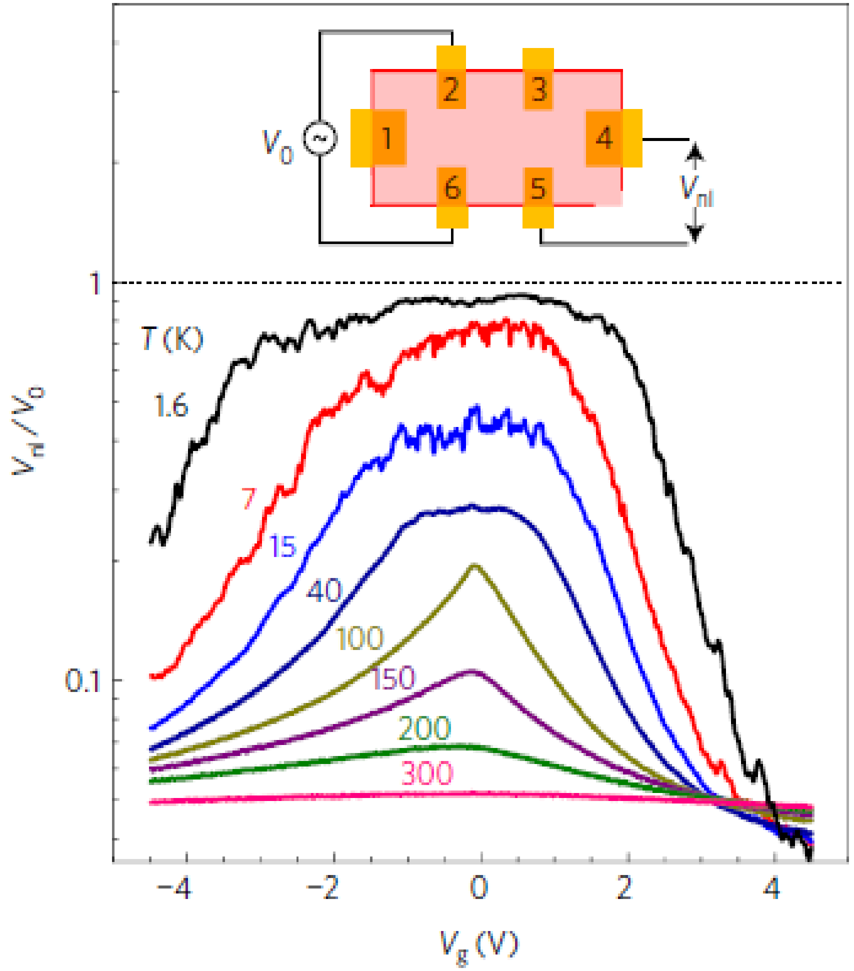




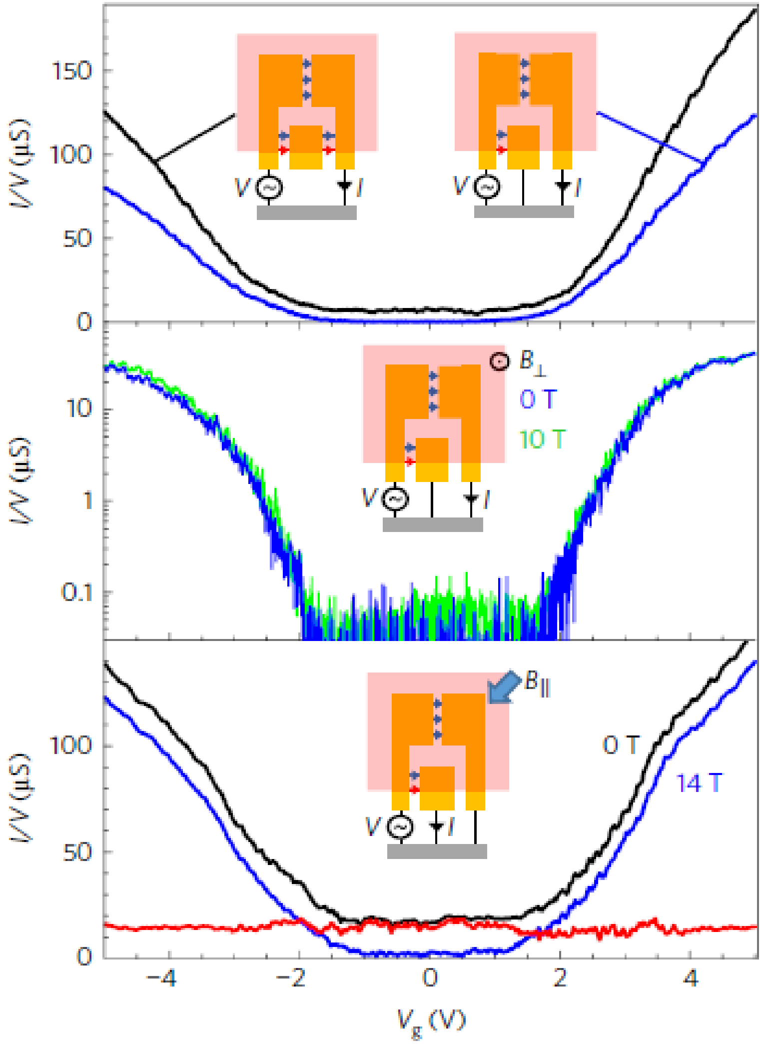


- Experimental results & explanations

Distinguishing edge and bulk conduction



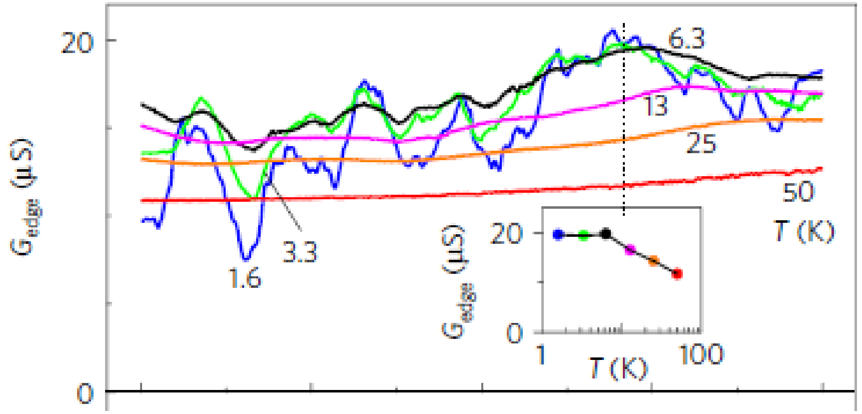
Traditional nonlocal measurement to detect edge conductance



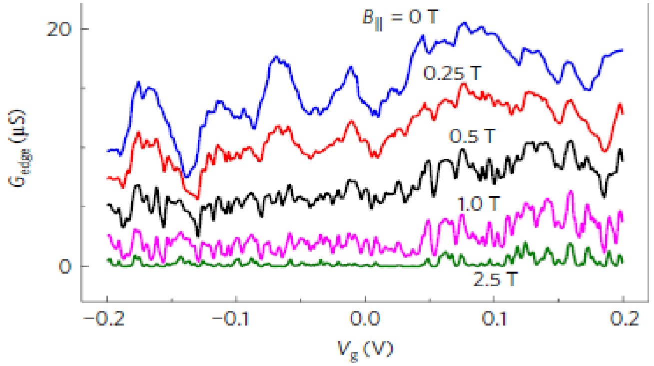
Quantitative separation of bulk and edge contributions

• Experimental results & explanations

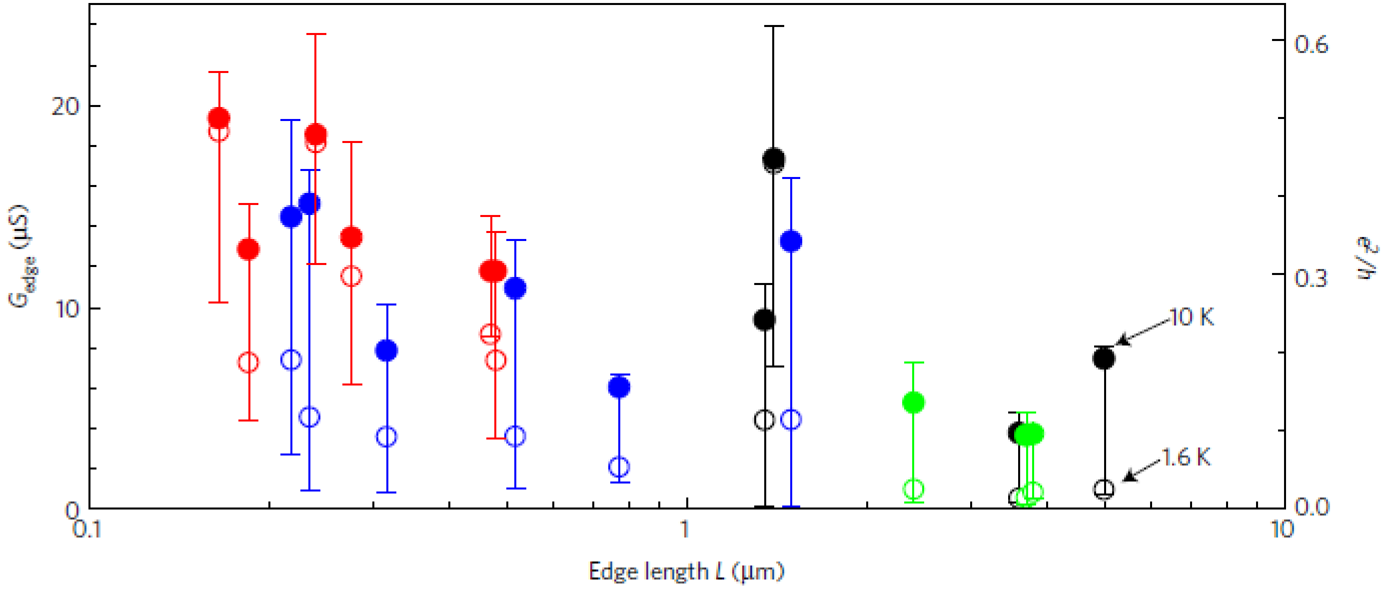
Distinguishing edge and bulk conduction



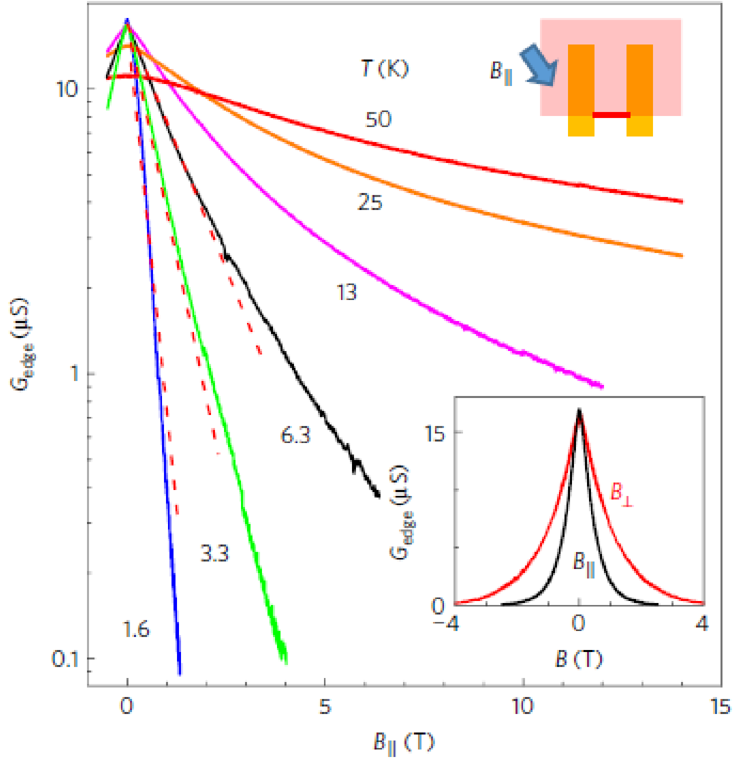
Temperature dependence of the conductance G_{edge} at zero magnetic field



Effect of in-plane magnetic field $B_{//}$ at 1.6 K



Gate-averaged linear-response edge conductance for 19 adjacent-contact pairs



Sweeps of $B_{//}$ at Vg=0 for various temperatures

◦ Experimental results & explanations

Some explanations

- The monolayer edge conductance is independent of Vg. This is consistent with a single gapless mode, and not with carrier accumulation due to band bending.

- No edge conduction in bilayers. This can be explained by the fact that TR symmetry does not prohibit backscattering at the bilayer edge.

- The conductance is dramatically suppressed by $B_{//}$, consistent with the expectation that elastic backscattering is allowed once TR symmetry is broken.

Summary

- At temperatures below about 100 K, monolayer WTe_2 does become insulating in its interior, while the edges still conduct.
- The edge conduction is strongly suppressed by an in-plane magnetic field and is independent of gate voltage.
- significant elastic scattering in the edge.