Emergence of zero-energy bound state in a magnet/superconductor heterostructure: $MnTe/Bi_2Te_3/FeTe_xSe_{1-x}$

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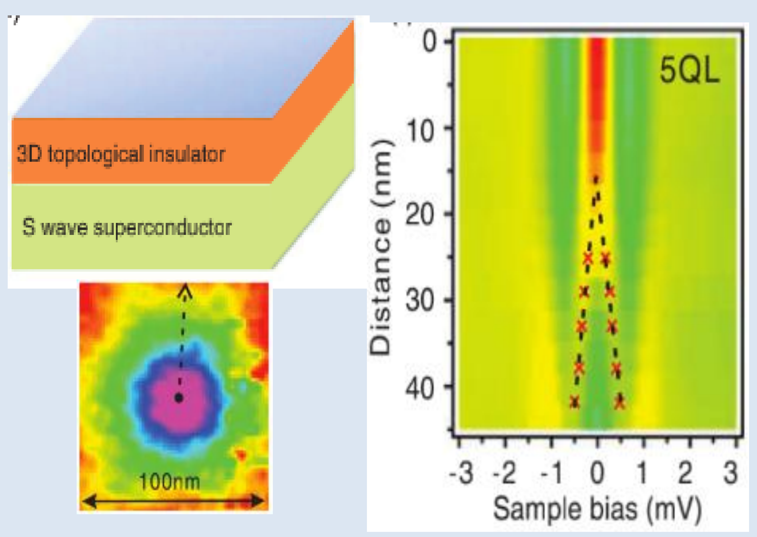
I. *why FM/TI/SC heterostructures*

SC/TI: Majorana zero mode

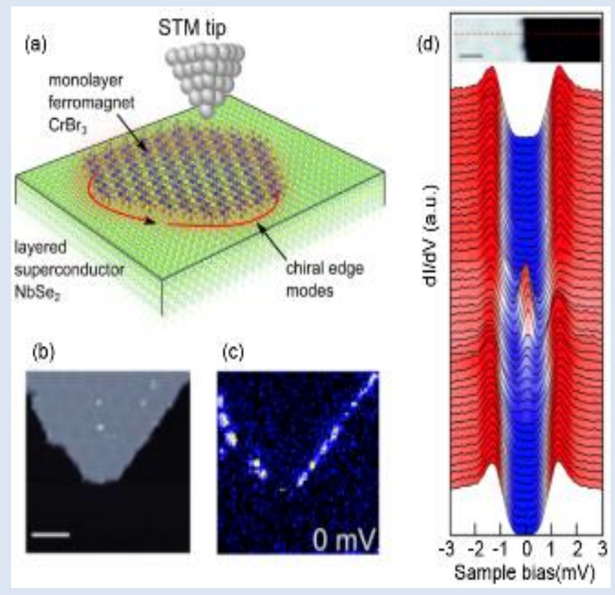
$Bi_2Te_3/NbSe_2$ (TI/SC)



J. P. Xu et al, Phys. Rev. Lett. 114, 017001 (2015)

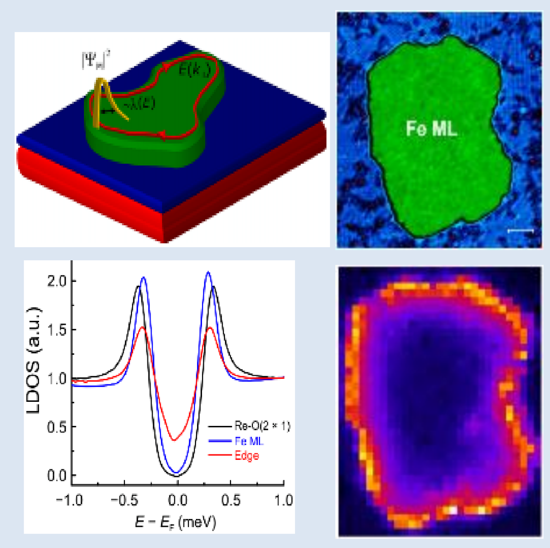
FM/SC: topological edge state, triple pairing

$CrBr_3/NbSe_2$ (Ferromagnet/SC)



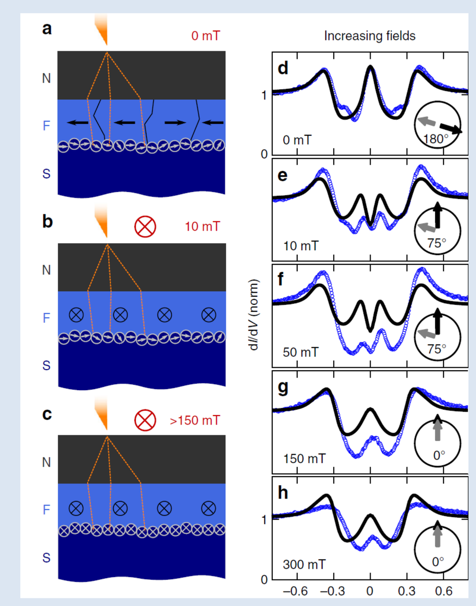
S. Kezilebieke et al, Nature: 588.424-428 (2020)

Fe/Re(0001) (Magnet/SC)



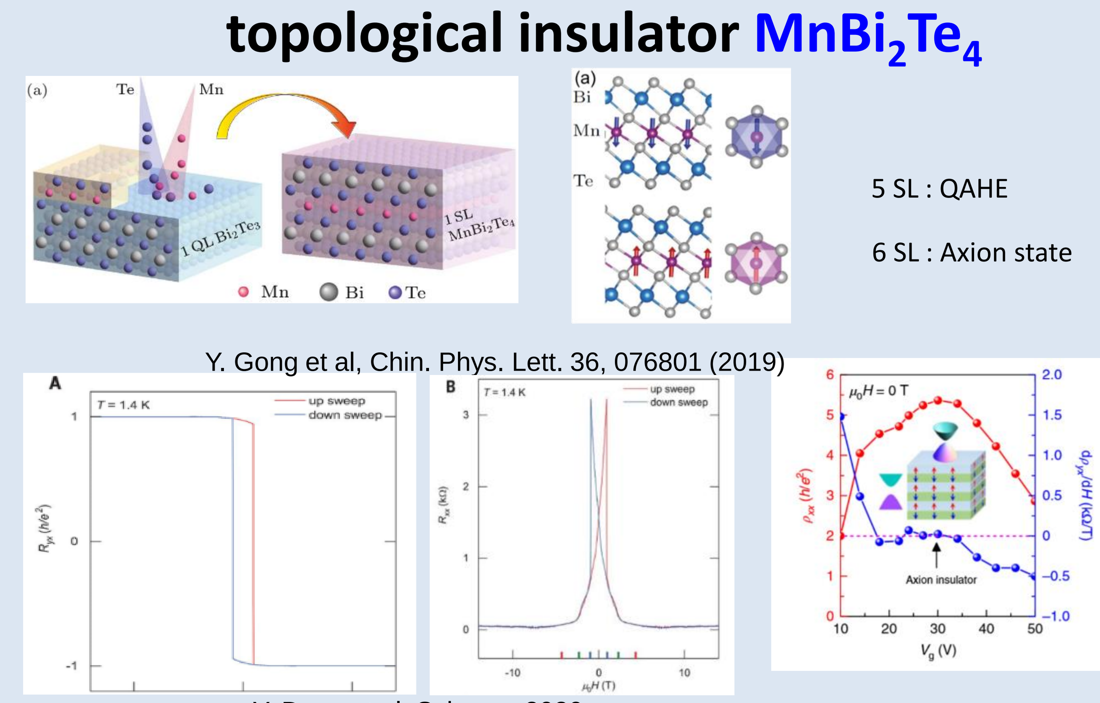
A. P. Morales et al, Sci. Adv. 5: eaav6600 (2019)

Al/EuS(SC/Magnet)



S. Diesch et al, Nat. Comm. 9, 5248 (2018)

FM/TI: 2D vdWs magnetic topological insulator $MnBi_2Te_4$



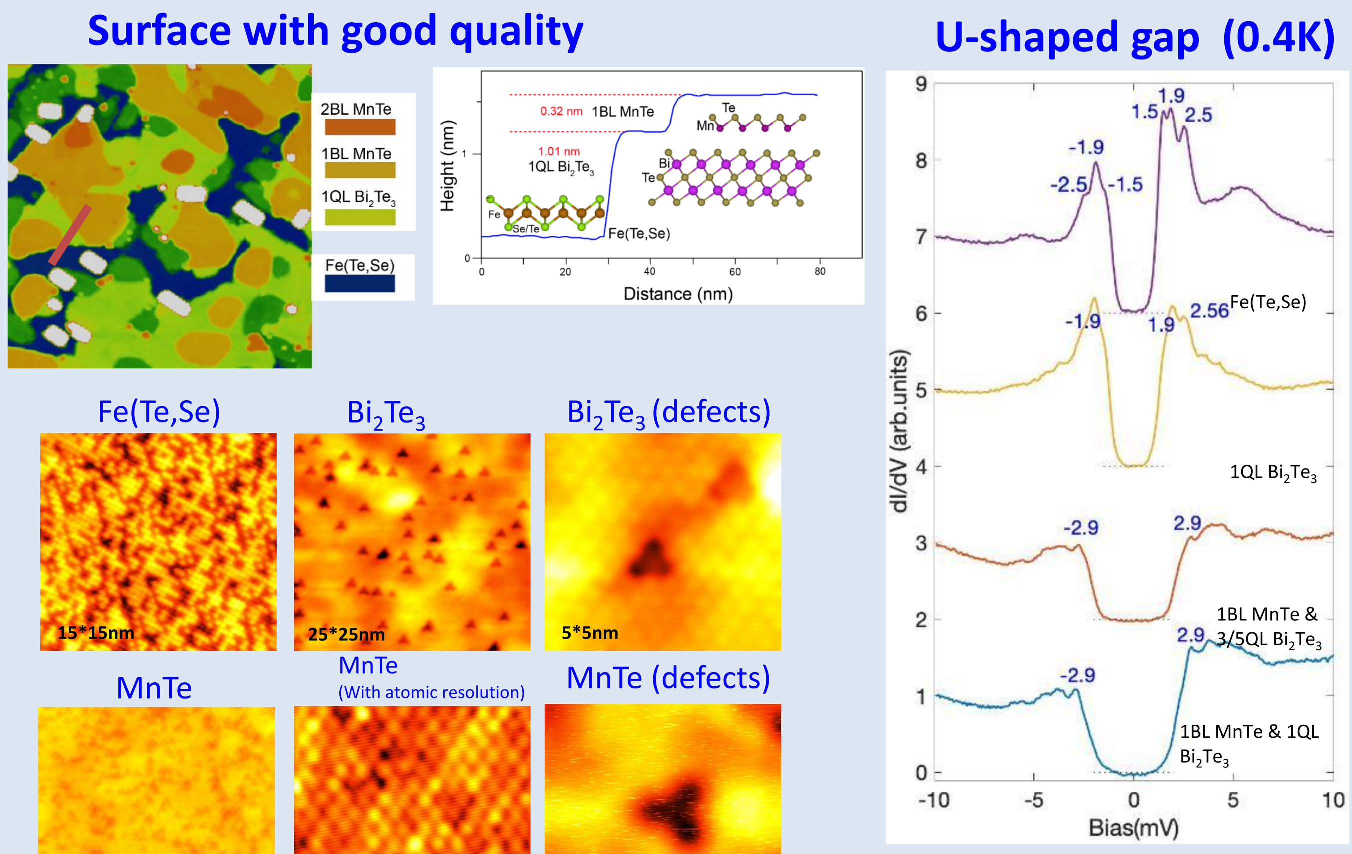
Y. Gong et al, Chin. Phys. Lett. 36, 076801 (2019)

Y. Deng et al, Science, 2020, eaax8156（2020）

C. Liu et al, , Nature Materials,19, 522–527(2020)

II. Experiments

Growth of $MnTe/Bi_2Te_3/Fe(Te,Se)$ heterostructure by MBE

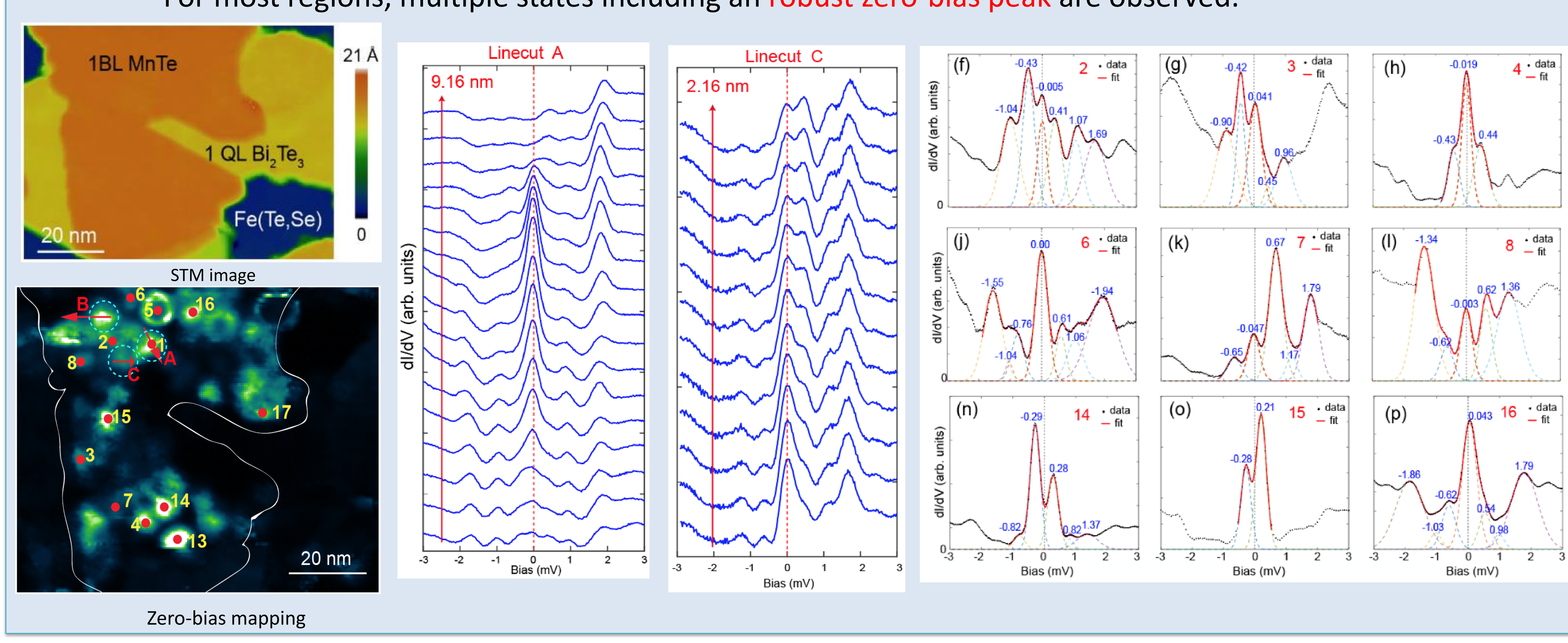


Enhanced gap (~3 meV) can be found on some region of 1BL MnTe !

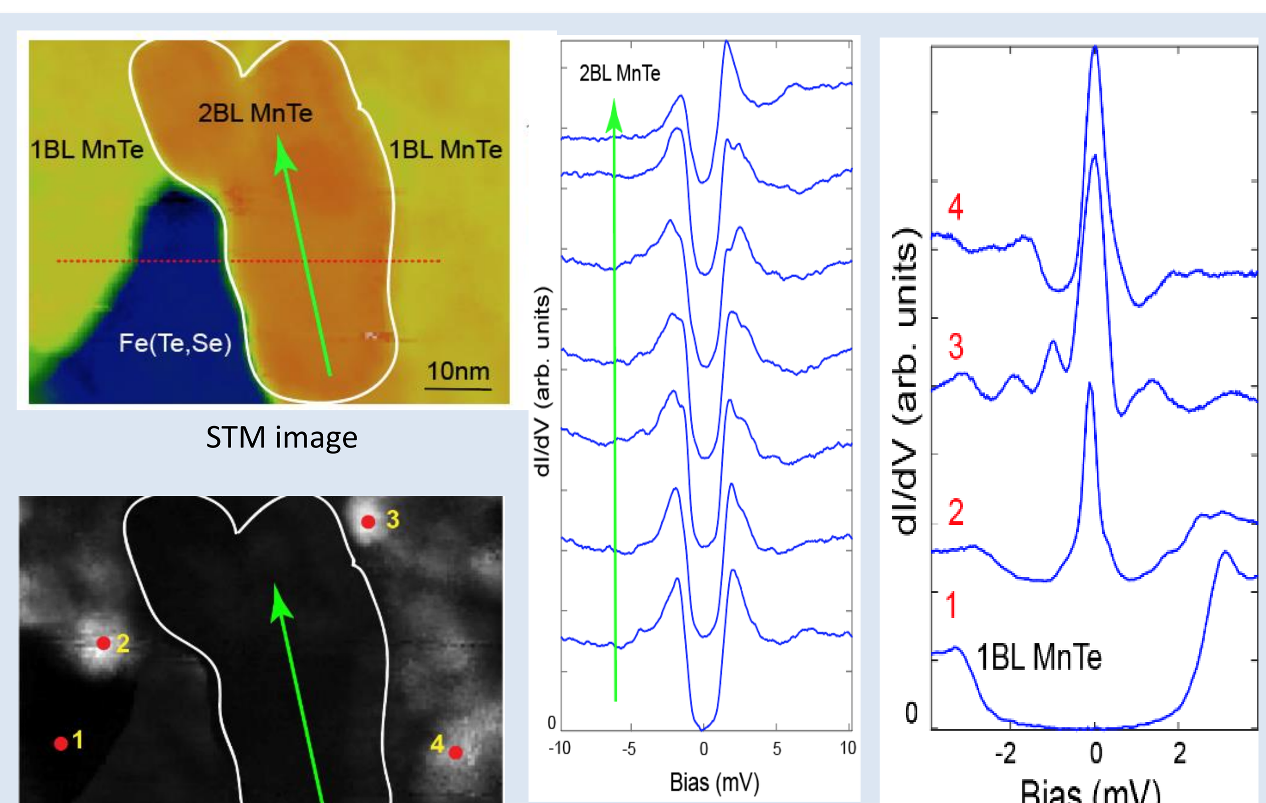
In-gap states on 1BL MnTe surface (B=0T, 0.4K)

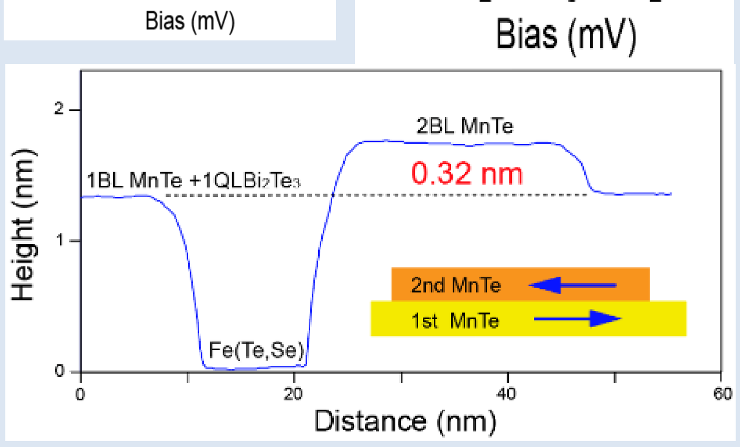
Zero-bias mapping shows randomly distributed regions with in-gap states on 1BL $MnTe/Bi_2Te_3/Fe(Se,Te)$

For most regions, multiple states including an robust zero-bias peak are observed.



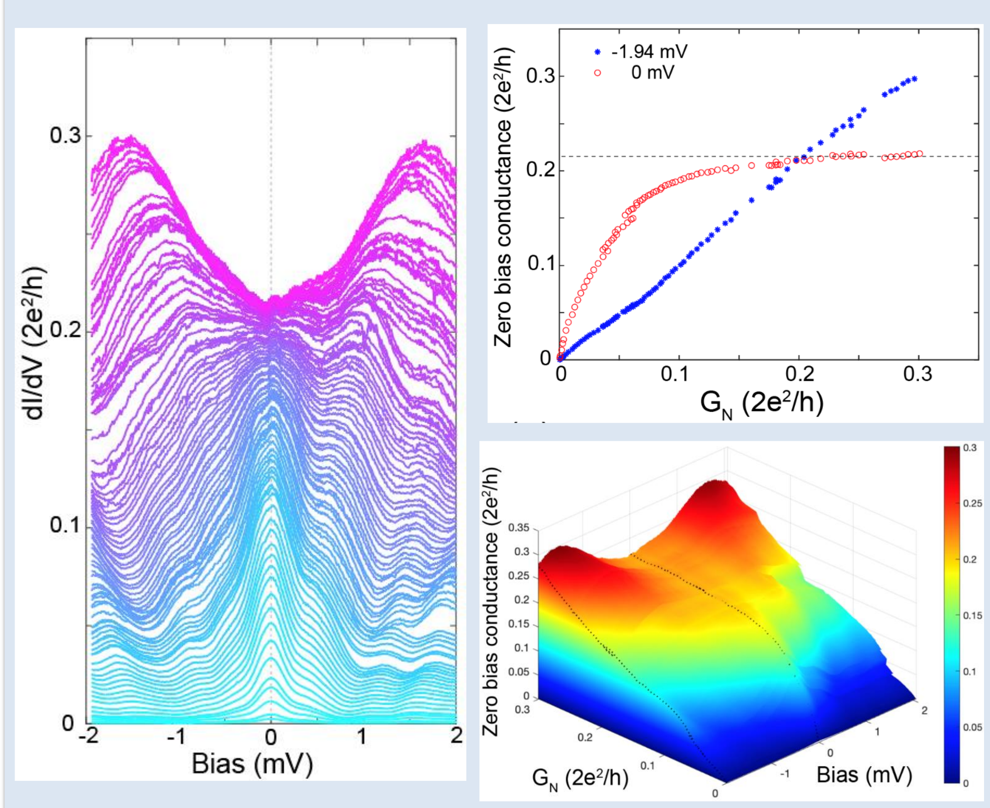
Absence of in-gap state in 2BL MnTe surface





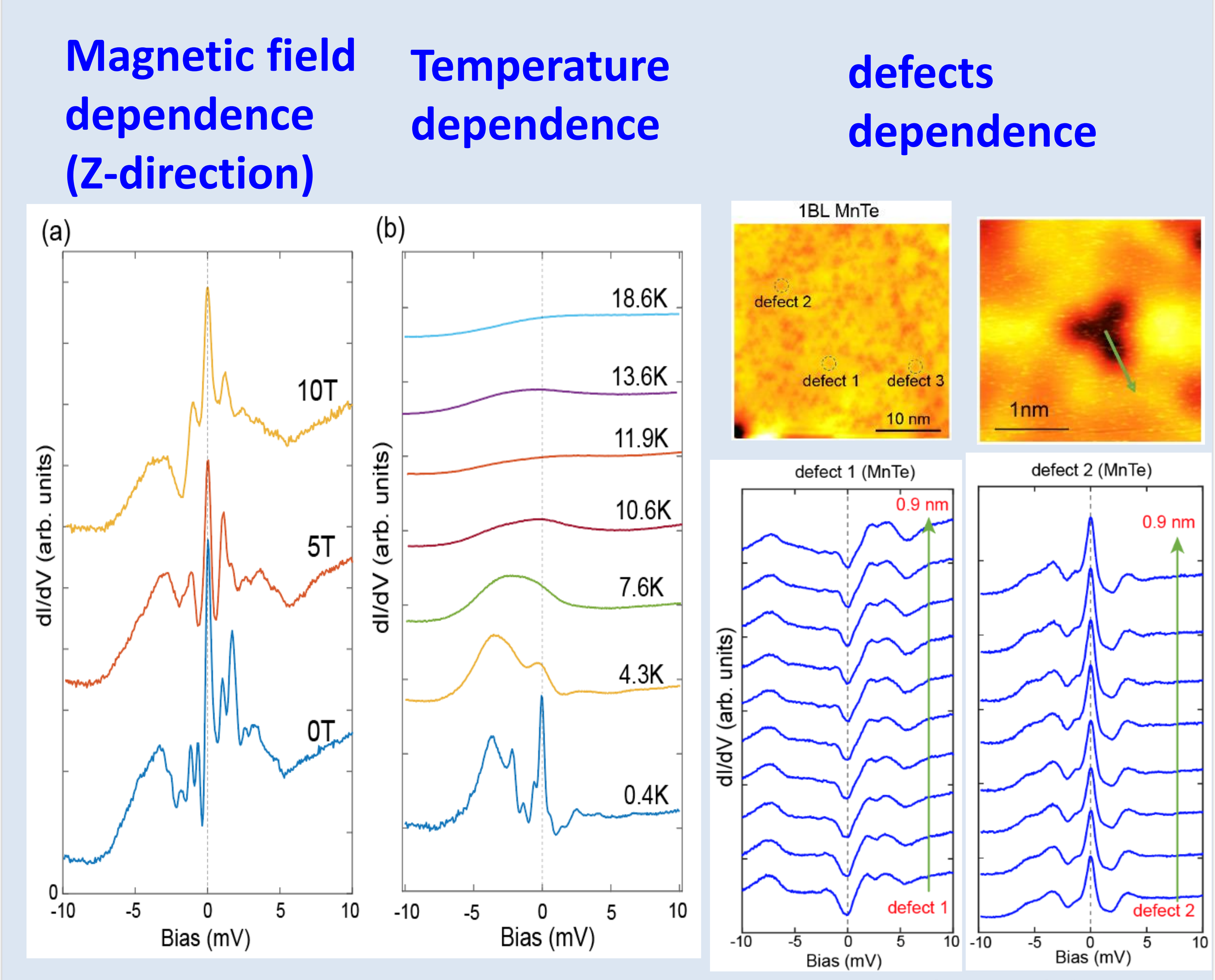
In-gap states disappear in the 2BL MnTe with AFM order.

Plateau behavior of the zero energy mode



conductance of ZBCP saturates at 0.22 G_0(=$2e^2/h$) and side peaks exceed it that the *dI/dV* turns into a "gap"-like signature

Response to external magnetic field, temperature and defects



No split!

Not induced by defects

III. Conclusions

- ➢We successfully grow $MnTe/Bi_2Te_3/Fe(Te,Se)$ heterostructure using MBE method
- ➢The size of superconducting gap (~2.9 meV) on 1BL MnTe is enhanced compared to the gap of Fe(Te,Se) or Bi_2Te_3 layer (~1.9 meV)
- ➢Many regions with in-gap state observed on single-layer MnTe. There are zero-energy state accompanied with multiple discrete states at B=0T, likely from the interplay between FM in the MnTe and SC substrate.
- ➢The regions with in-gap state disappear on 2BL MnTe, likely due to the antiferromagnetic coupling between 2BL MnTe.