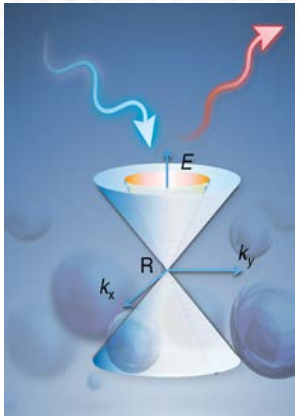
Observation of Double Weyl Phonons in Parity-Breaking FeSi

Mark P. M. Dean, Hu Miao et al.,

Brookhaven National Laboratory



Inelastic X-Ray Scattering 2019

Stony Brook

June 24th, 2019

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Observation of Double Weyl Phonons in Parity-Breaking FeSi

H. Miao,[1,*,‡] T. T. Zhang,[2,3,‡] L. Wang,[2,3,‡] D. Meyers,[1] A. H. Said,[4] Y. L. Wang,[1] Y. G. Shi,[2]
H. M. Weng,[2,5] Z. Fang,[2,5] and M. P. M. Dean[1,†]

[1]*Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory, Upton, New York 11973, USA*
[2]*Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China*
[3]*University of Chinese Academy of Sciences, Beijing 100049, China*
[4]*Advanced Photon Source, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[5]*Collaborative Innovation Center of Quantum Matter, Beijing 100190, China*

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Hu Miao
Derek Meyers
Yilin Wang

Theory
Tiantian Zhang
Zhong Fang
Hongming Weng

Beamline
Sector 30 APS
Ayman Said

Samples
IoP CAS

We have open post-doc positions
irobinson@bnl.gov (or mdean@bnl.gov)

Topological physics in the solid state

Types of topological physics

1. Non-abelian
2. Band structures

2 is applicable in any system with quasiparticles

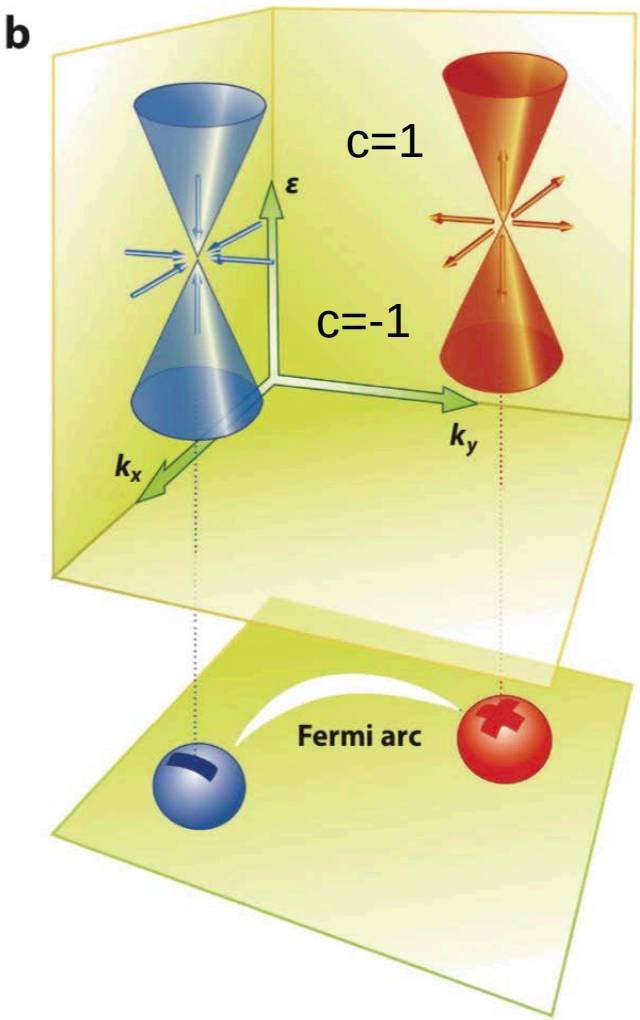
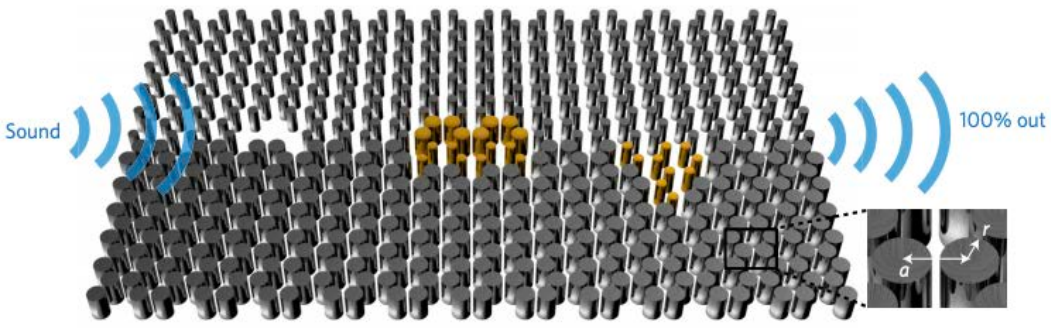
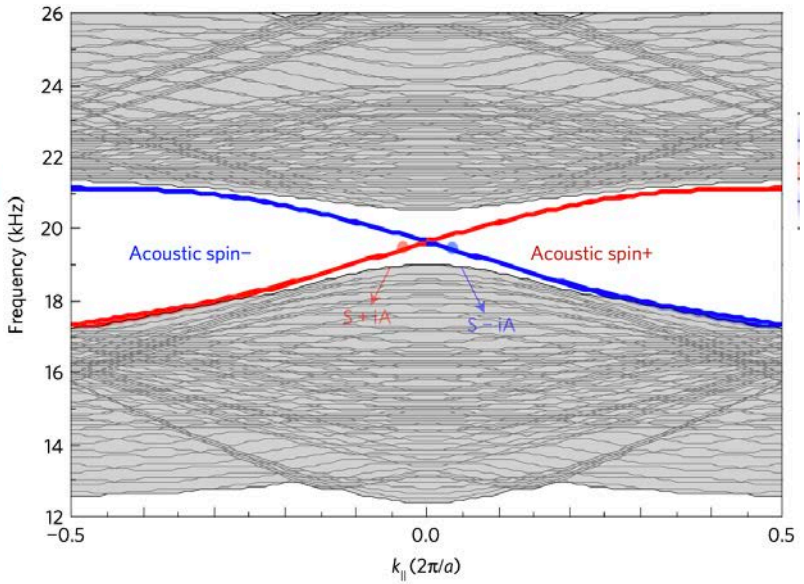


Image: M.Z. Hassan

S.-Y. Xu et al. *Science* 349:613–17 (2015)
B.Q. Lv, et al. *Phys. Rev. X* 5:031013 (2015)

kHz one-way sound transport





a = 1 cm

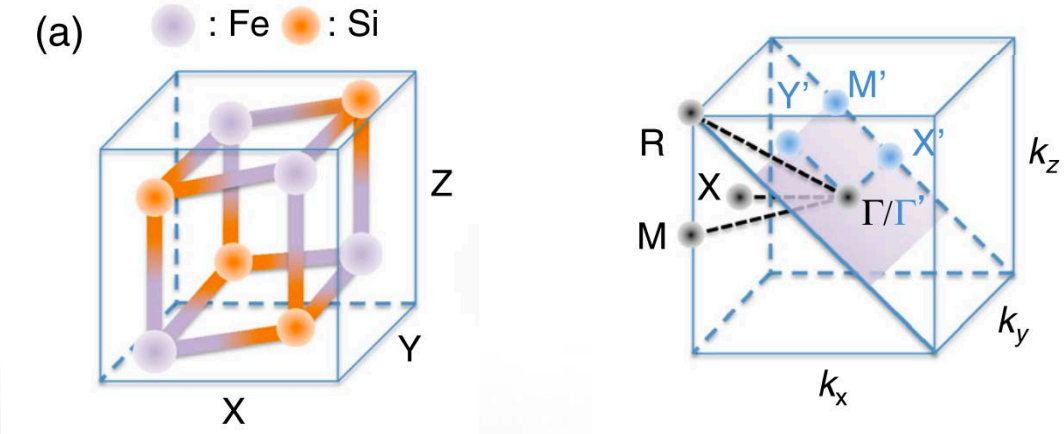
Cheng He et al., *Nature Physics* **12**, 1124–1129 (2016)

Can topological physics be realized natural crystals?

*M*Si where *M*=Fe, Co, Mn, Re, Ru

SG $P2_13$ (No. 198)

Break PT symmetry

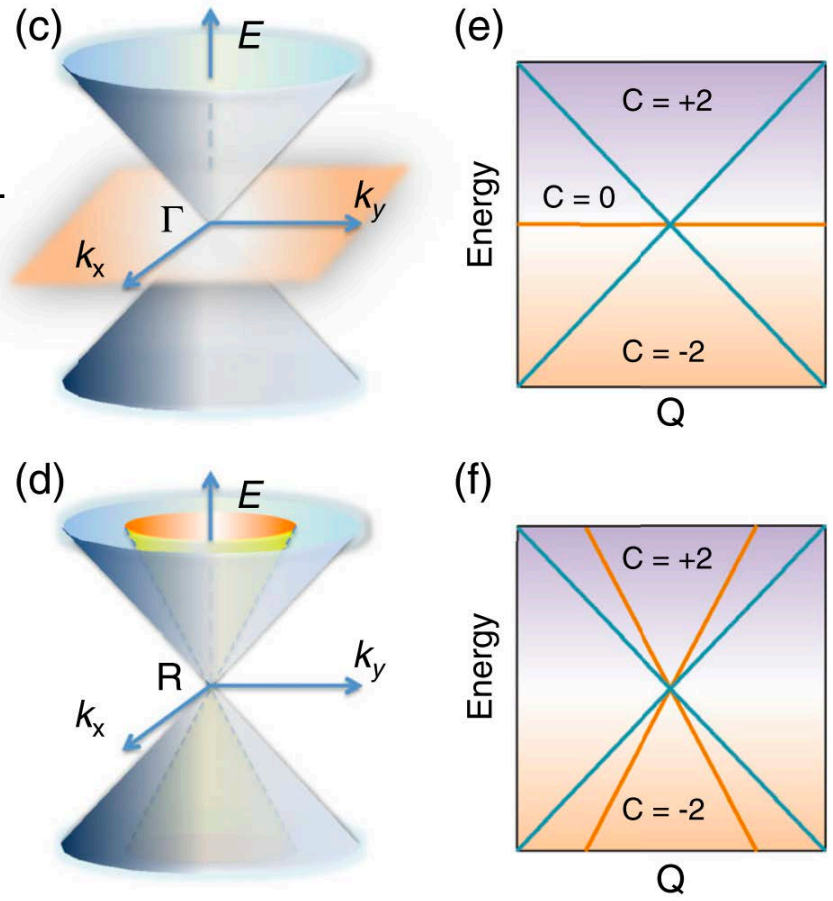


Tiantian Zhang et al., *Phys. Rev. Lett.* 120, 016401 (2018)

Double Weyl Points in FeSi

Double Weyl points

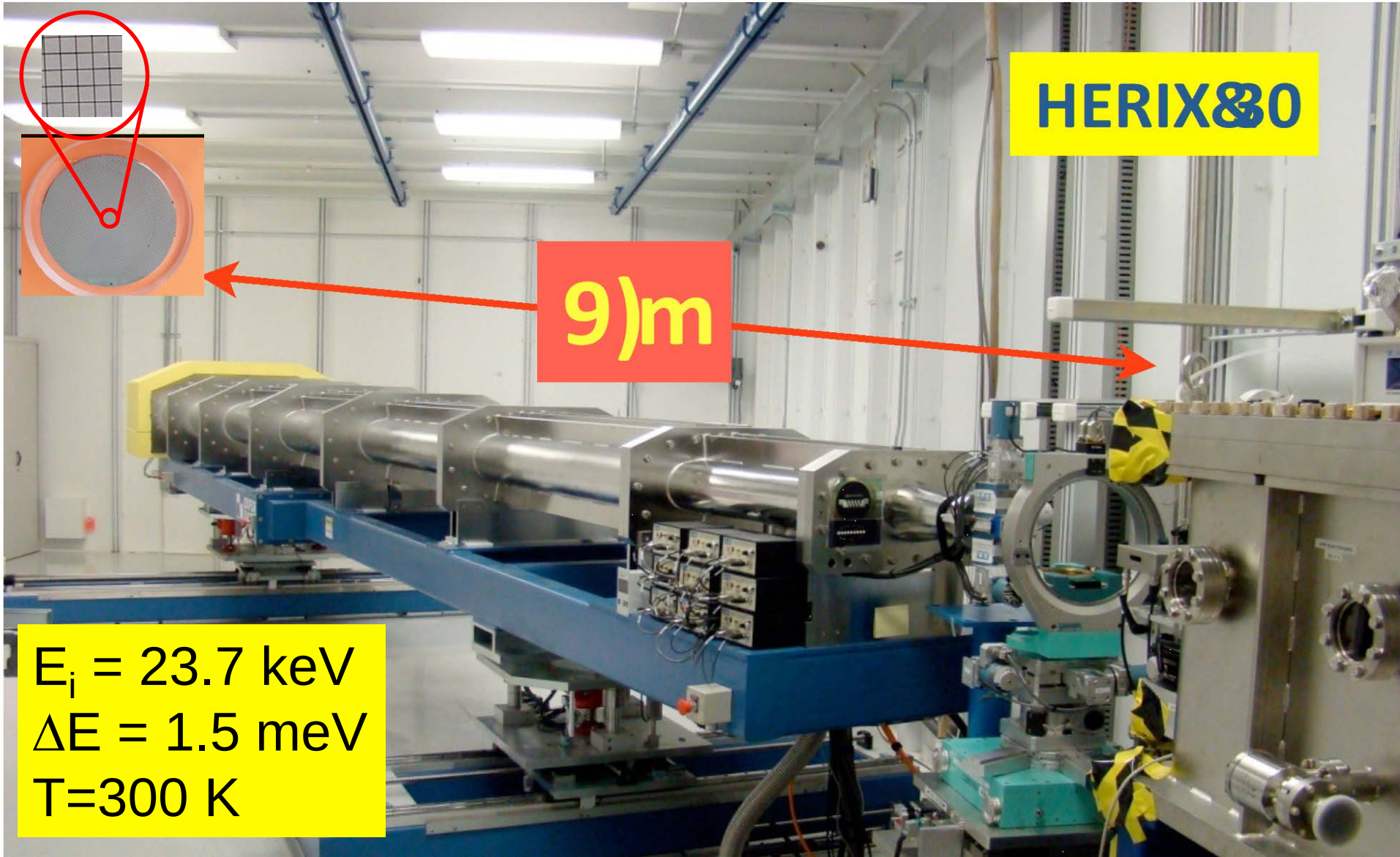
Effective spin 1 Weyl



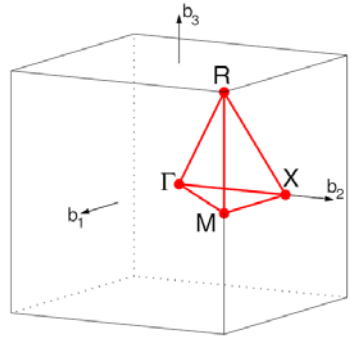
Effective Charge 2 Dirac

Tiantian Zhang et al., *Phys. Rev. Lett.* 120, 016401 (2018)

Inelastic x-ray scattering

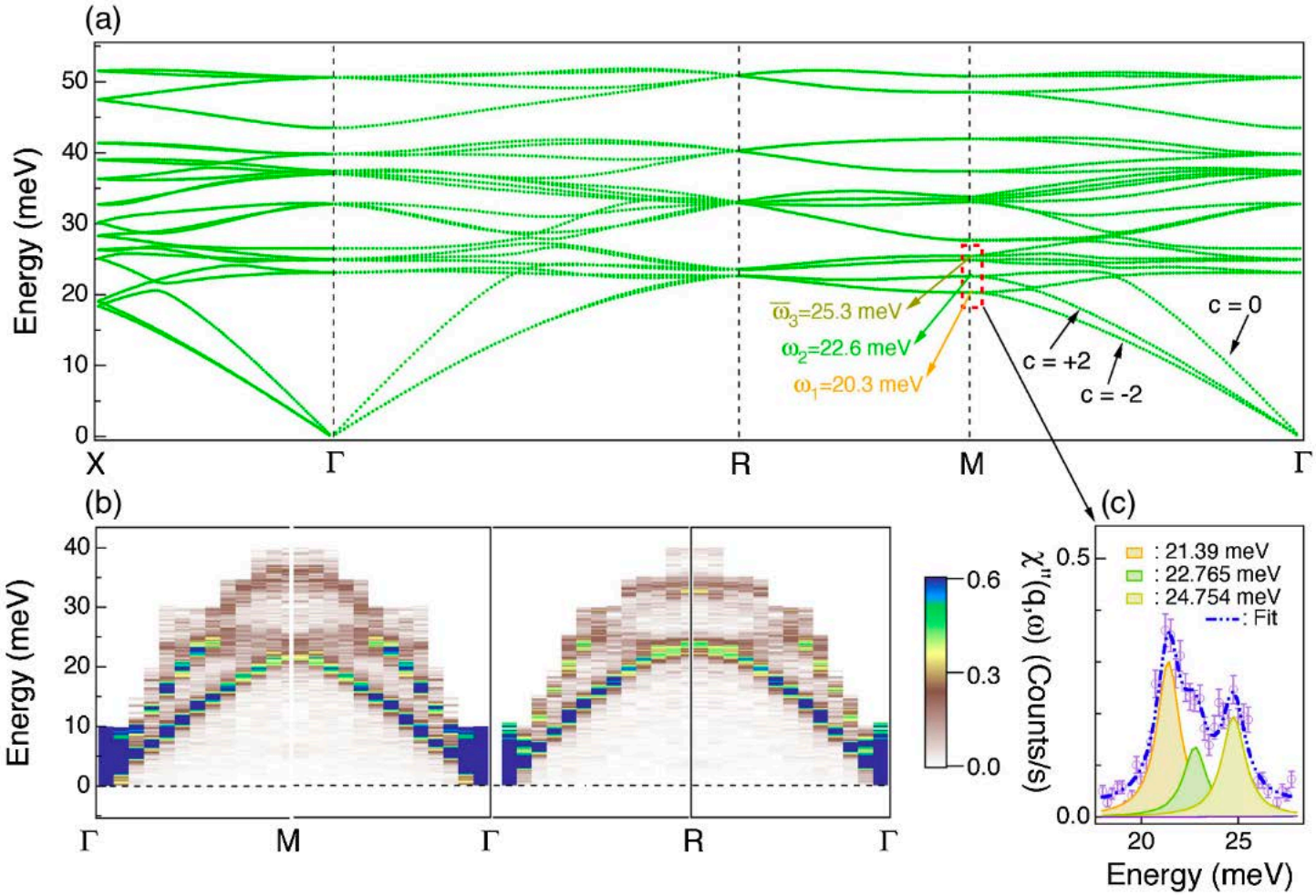


Effective spin 1 Weyl Point

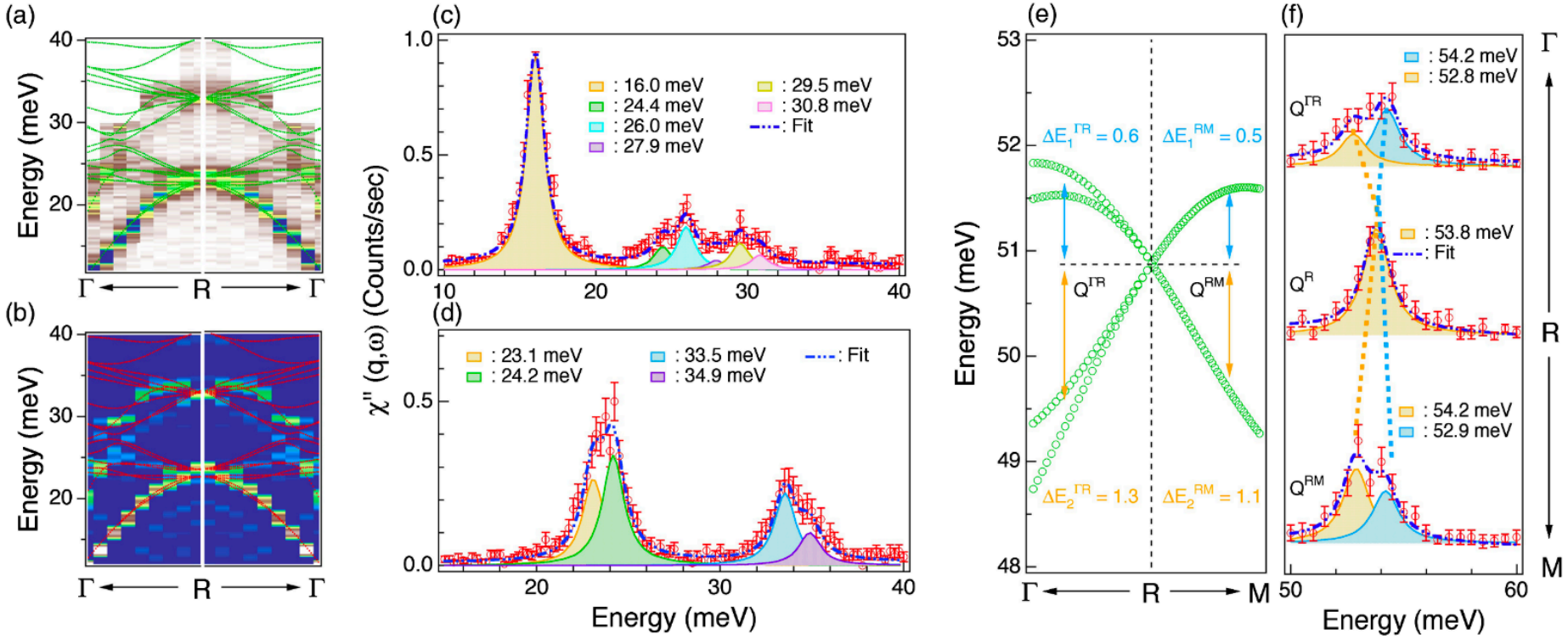


CUB path: Γ-X-M-Γ-R-X|M-R

[Setyawan & Curtarolo, DOI: 10.1016/j.commatsci.2010.05.010]



Effective charge-2 Dirac point



Why might this be interesting?

Phonons are important in condensed matter

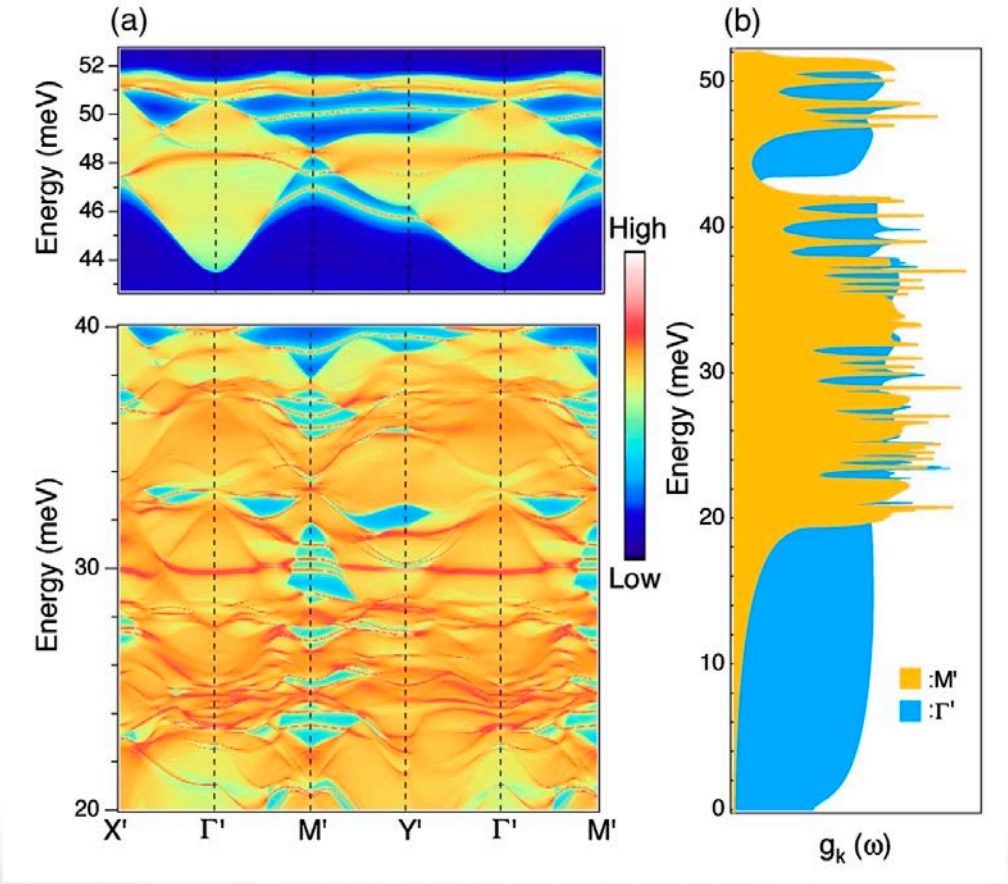
Non-trivial transport of phonons / heat /information

Unique symmetry properties? SOC

Bosonic statistics

S. Singh et al., Phys. Rev. Mat. 2, 114204 (2018)

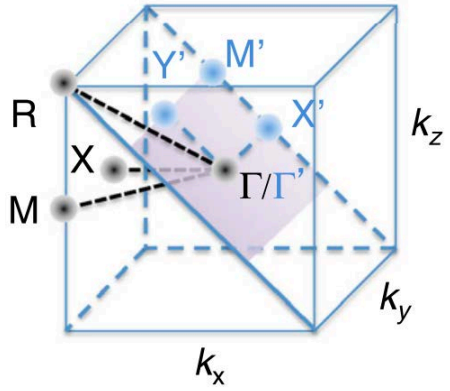
Surface modes



110 Surface

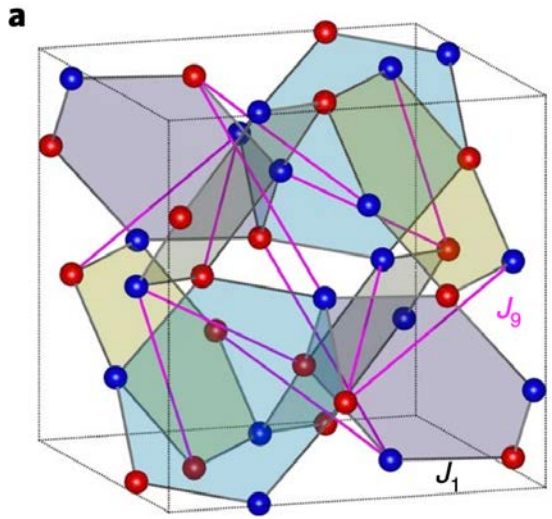
Arc state around 50 meV

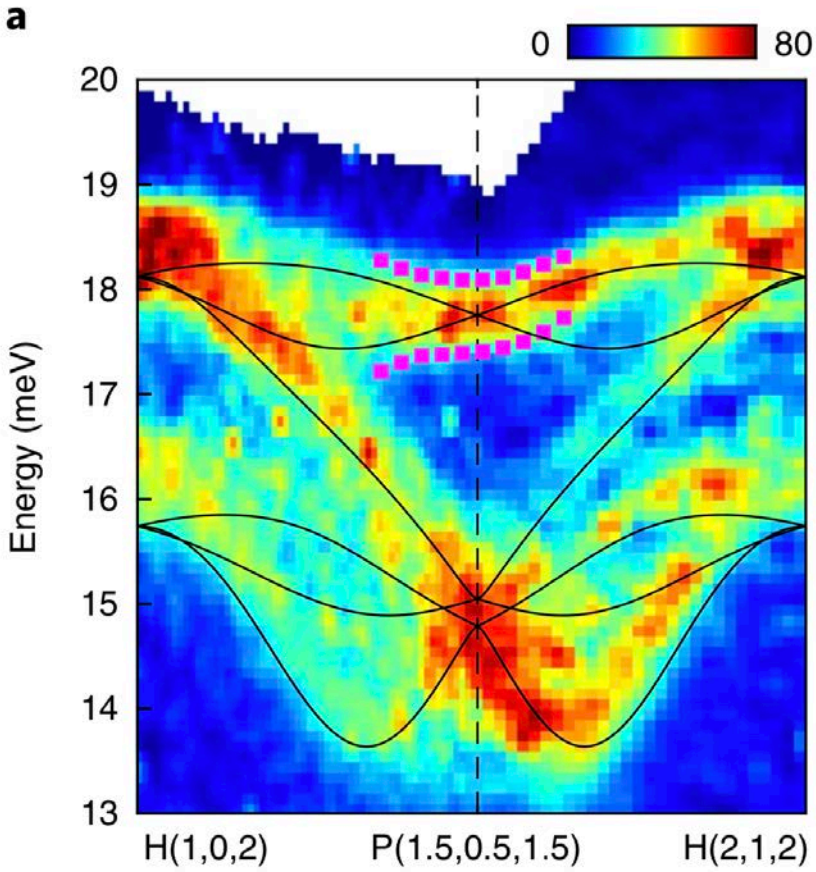
Minimal overlap with bulk modes



Topological magnons

Cu_3TeO_6





W. Yao et al., Nature Physics 14, 1011–1015 (2018)
R. Chisnell et al., Phys. Rev. Lett. 115, 147201 (2015)

Conclusions

- First experimental observation of phonon double Weyl points
- These modes musts terminate in non-trivial surface states
- Potential for new routes towards protected phonon transport at the nanoscale

We have open post-doc positions For (R)IXS and coherent scattering! mdean@bnl.gov