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
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. Dean¹,‡

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

(Received 27 April 2018; published 18 July 2018)

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

Theory
Tiantian Zhang
Zhong Fang
Hongming Weng

Beamline
Sector 30 APS
Ayman Said

Samples
IoP CAS
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

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?

\[ MSi \] where \( M = \text{Fe, Co, Mn, Re, Ru} \)

\[ \text{SG } P2_13 \text{ (No. 198)} \]

Break \( PT \) symmetry

Double Weyl Points in FeSi

Inelastic x-ray scattering

$E_i = 23.7 \text{ keV}$

$\Delta E = 1.5 \text{ meV}$

$T = 300 \text{ K}$
Effective spin 1 Weyl Point

(a) Energy (meV)

(b) Energy (meV)

(c) χ''(q,ω) (Counts)
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

Surface modes

Arc state around 50 meV

Minimal overlap with bulk modes

110 Surface
Topological magnons

Cu₃TeO₆

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