Julius-Maximilians-
UNIVERSITÄT WÜRZBURG

MPI-CPfS Fellow status report

EP 3

Group of Prof. Dr. Laurens Molenkamp

EP III and ITI, Universität Würzburg

ct.qmat
Complexity and Topology in Quantum Matter

EP 3

ITI

Outline

1. Thermoelectric Properties of HgTe Weyl Semimetals (Moessner, PKS)

2. Ballistic and hydrodynamic transport in Delafossites (Mackenzie)

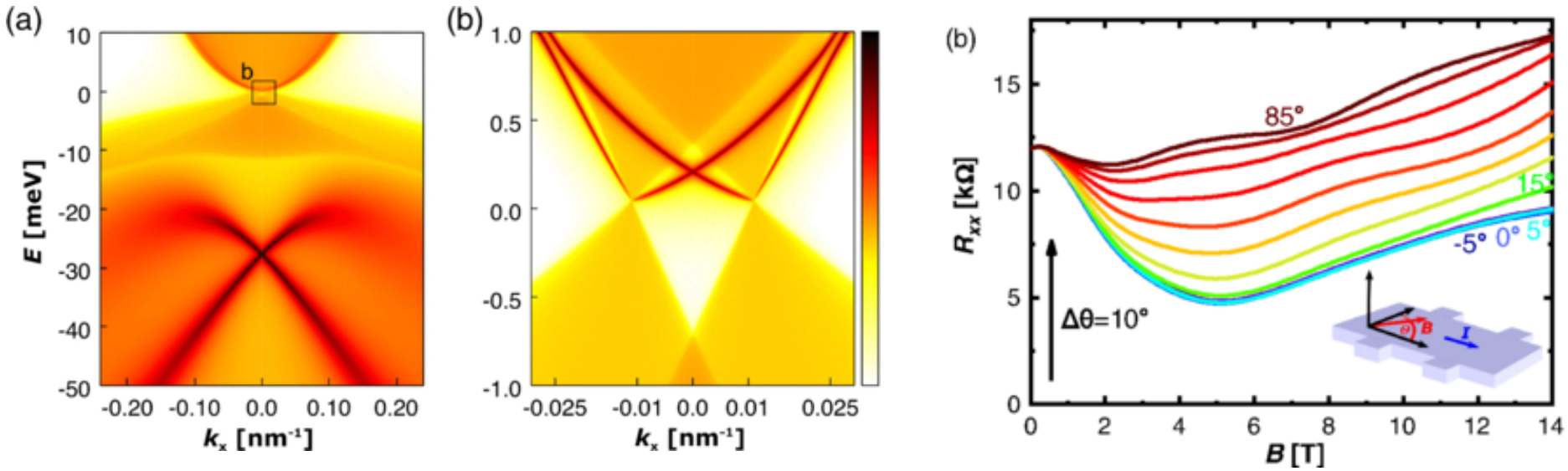
3. Effects of uniaxial strain on HgTe based topological materials (Mackenzie)

4. Molecular beam epitaxy of the topological superconductor YPtBi (Felser)

Topics 1-3: Ph.D. students Abu Aravindnath and Arya Thenapparambil

Topic 4: Postdoc Jiwoong Kim (ct.qmat)

Thermoelectric Properties of HgTe Weyl Semimetals



Mahler et al., Phys. Rev. X 9, 031034 (2019)

- Due to the outstanding quality of our HgTe layers, Fermi energy can be gated in the vicinity of the Weyl point, a situation which is hardly to be realized in other topological semimetals
- The goal of this project is to study the predictions related to the mixed axial-gravitational anomaly in Weyl semimetals.

$$\kappa\,(B) = \kappa\,(B = 0) + c_g k_B^2 B$$

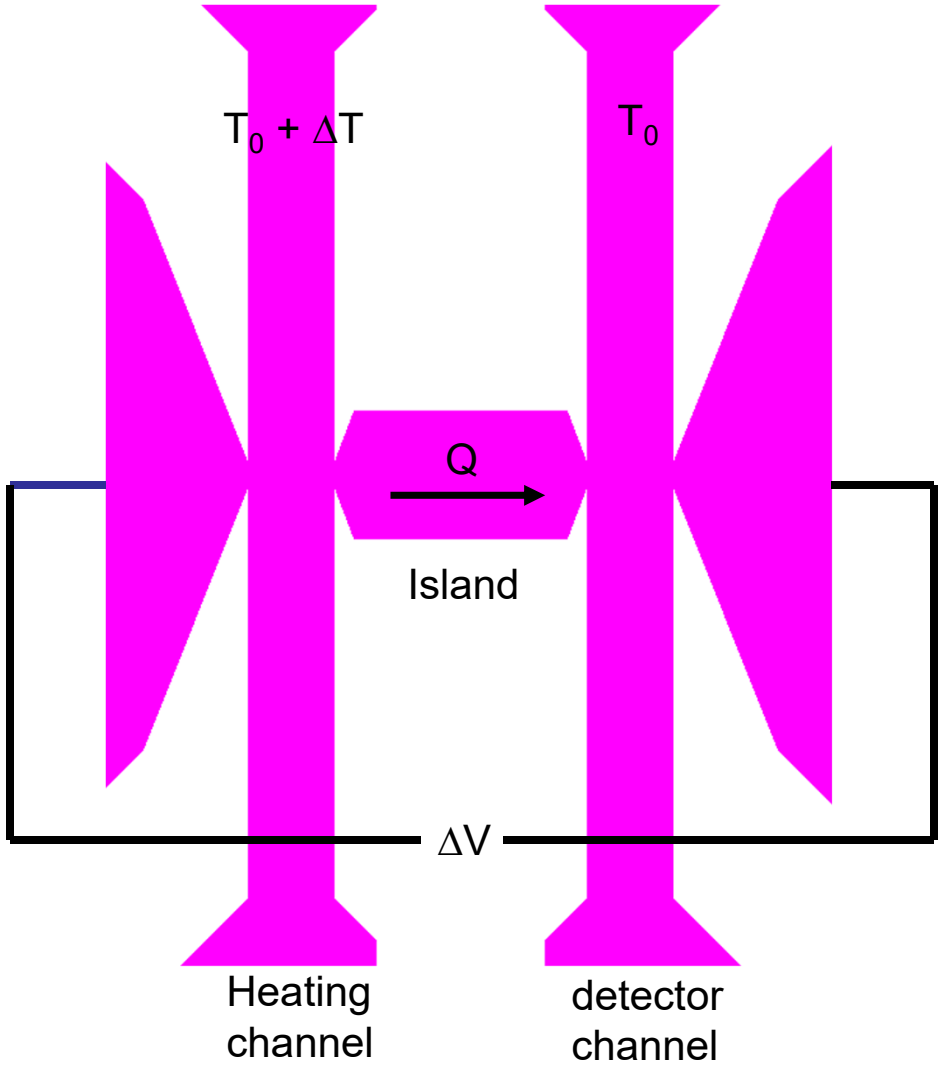
Dresden:
Francisco Peña-Benitez,
Piotr Surówka

Thermoelectric Properties of HgTe Weyl Semimetals

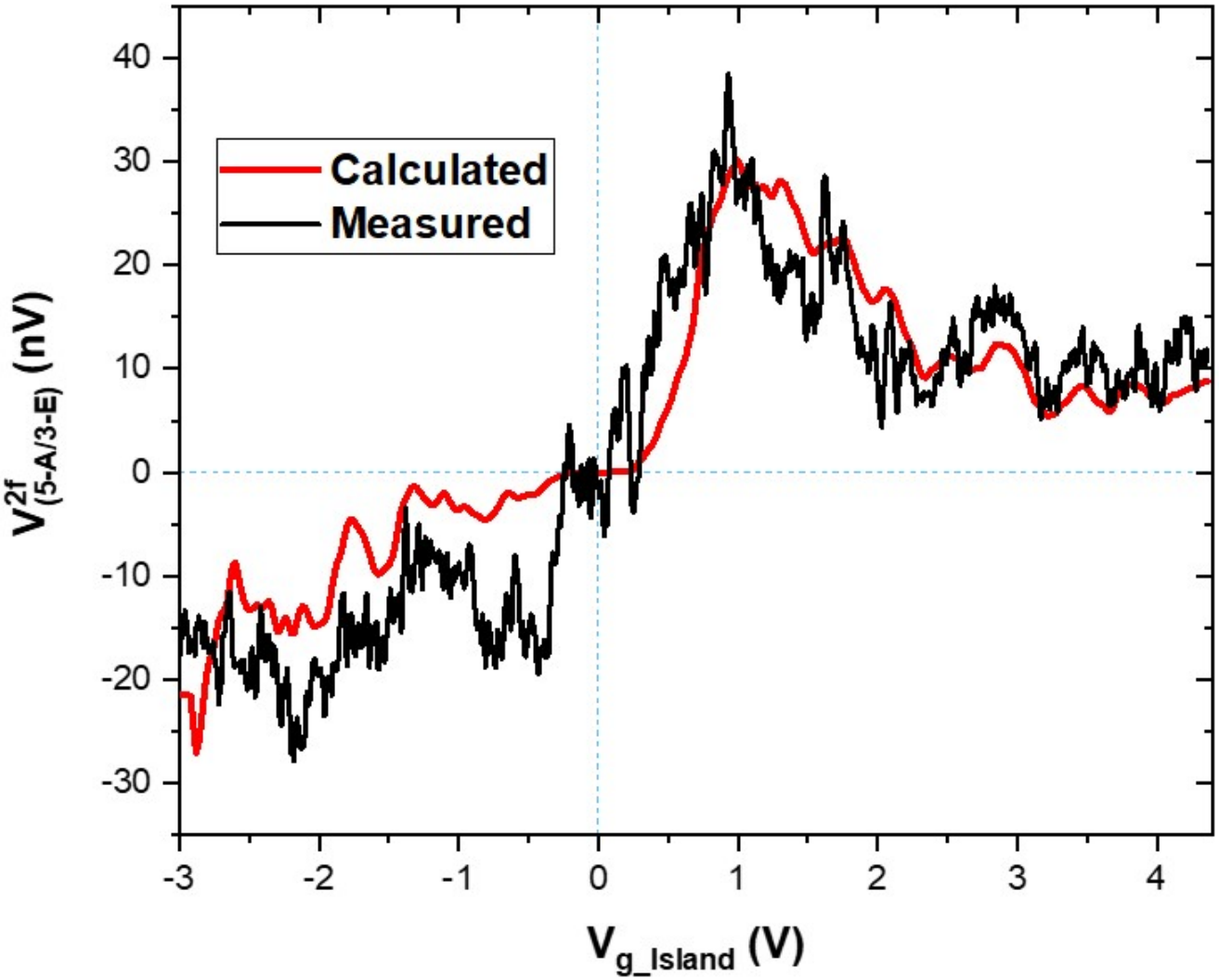
- We use current heating of the electron gas to create a temperature gradient across a Weyl semimetal island.
- Further properties such as the Seebeck coefficient can be calculated from the thermovoltage across the channel.

$$\begin{pmatrix} -\Delta V \\ Q \end{pmatrix} = \begin{pmatrix} R & S \\ \Pi & -\kappa \end{pmatrix} \begin{pmatrix} I \\ \Delta T \end{pmatrix}$$

$$\kappa = \left.\frac{Q}{\Delta T}\right|_{I=0} \qquad S = \left.\frac{\Delta V}{\Delta T}\right|_{I=0}$$



Thermoelectric Properties of HgTe Weyl Semimetals

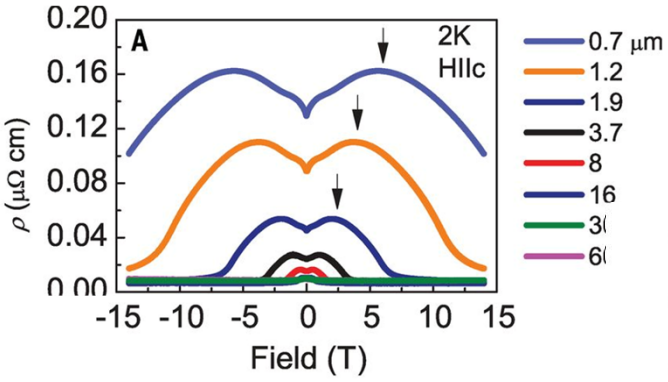


We have successfully measured the Seebeck coefficient in a HgTe Weyl semimetals and verified the validity of Mott's relation in our system.

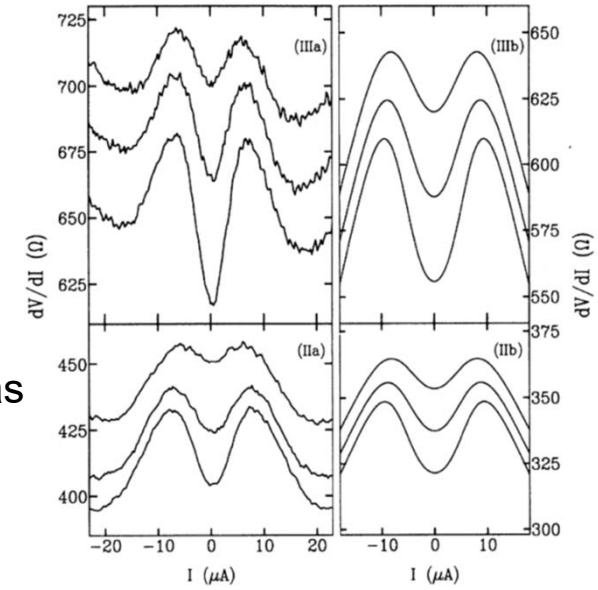
Ballistic and hydrodynamic transport transport in delafossites

Palladium cobaltate

PdCoO2 is a quasi-two-dimensional delafossite metal with exceptional electrical properties, including indications for hydrodynamic electron flow.

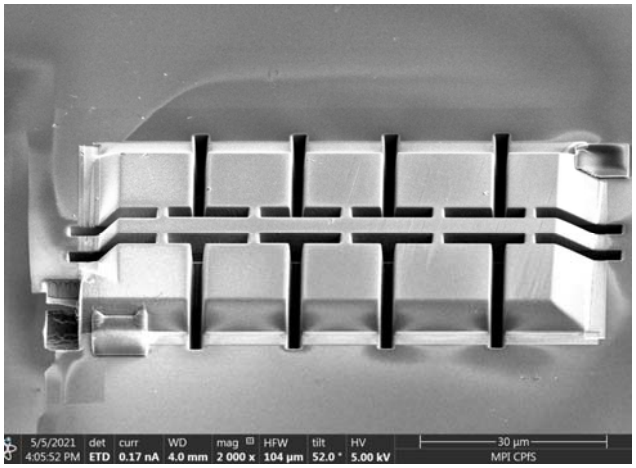


P. Moll et al.,
Science **351**, 1061 (2016)



Previously, hydrodynamic flow was demonstrated in 2DEGs using a current heating technique

Dresden:
Markus König



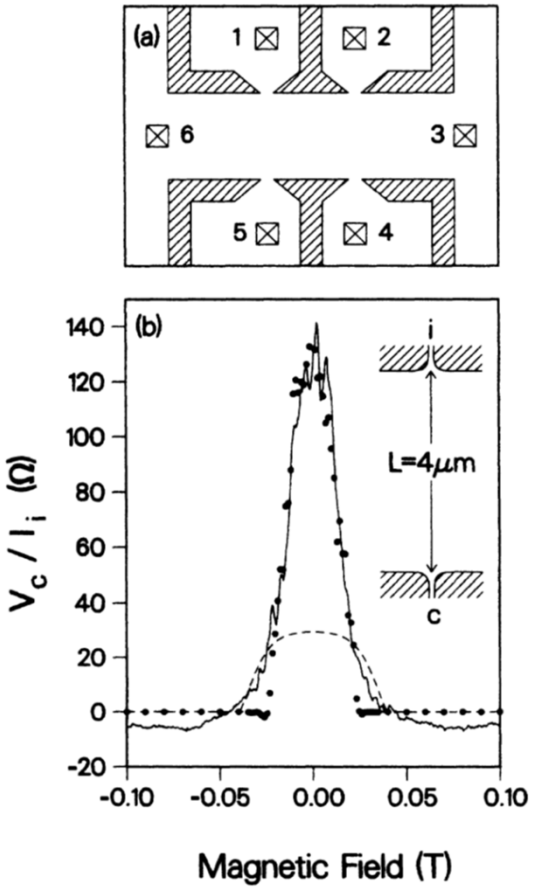
PdCoO2 crystals are grown, and transport devices are structured at the MPI Dresden, involving focused ion beam (FIB) techniques.
Developing tunnel barriers for the current contacts to enable current heating for driving hydrodynamic transport.

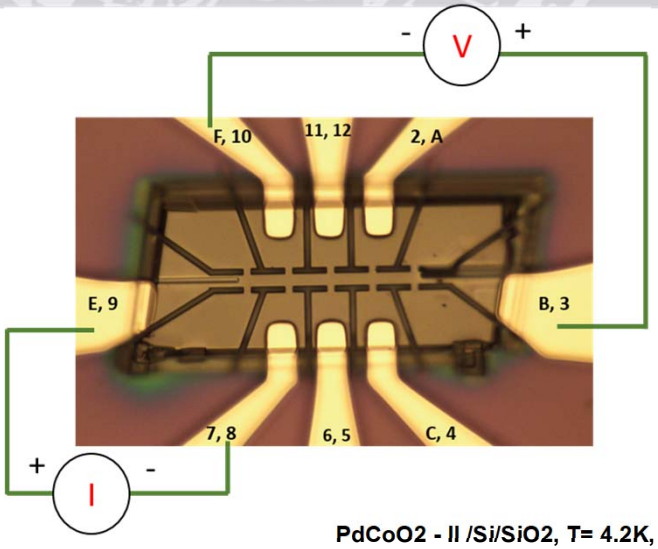
L.W. Molenkamp and M.J.M. de Jong
Physical Review B **49**, 5038 (1994)
M.J.M. de Jong and L.W. Molenkamp
Physical Review B **51**, 14489 (1995)

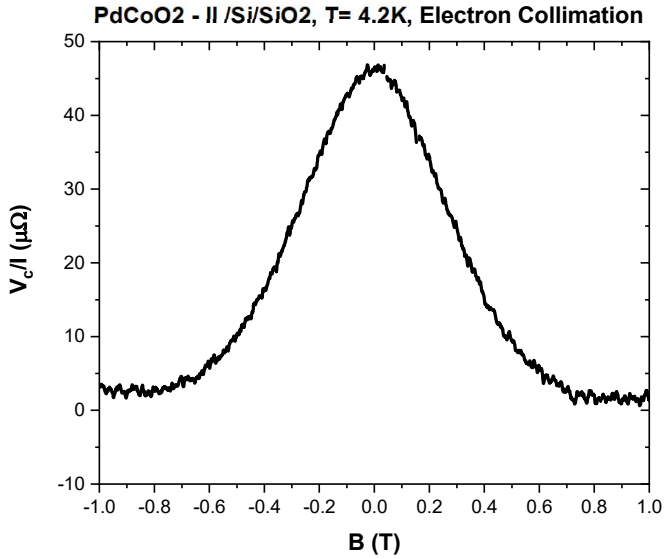
Ballistic and hydrodynamic transport in delafossites

Ballistic electron beams:

L.W. Molenkamp et al., Physical Review B **41**, 1274 (1990)

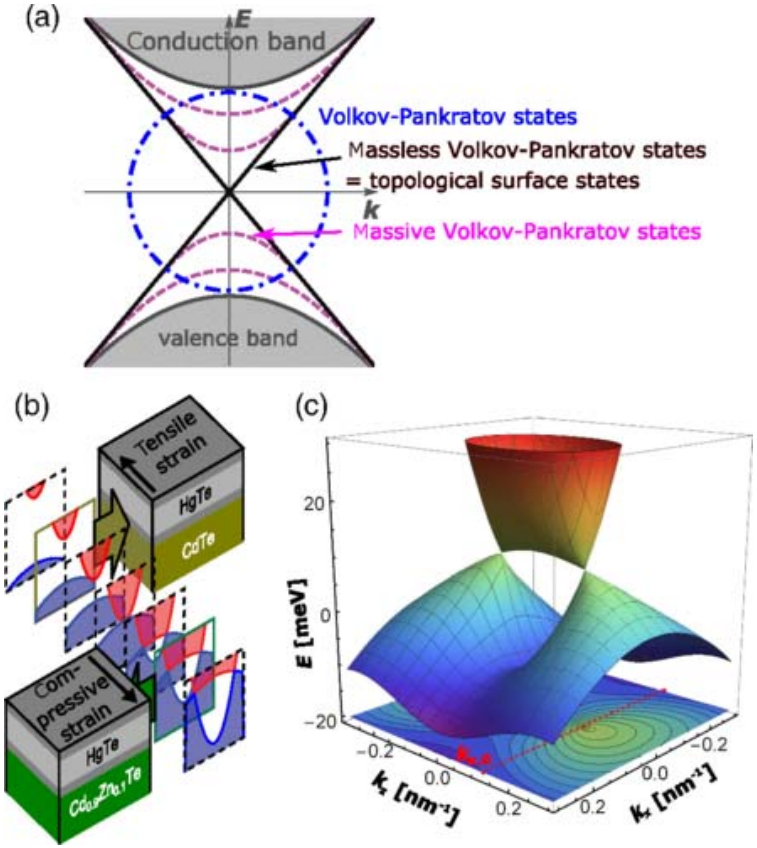






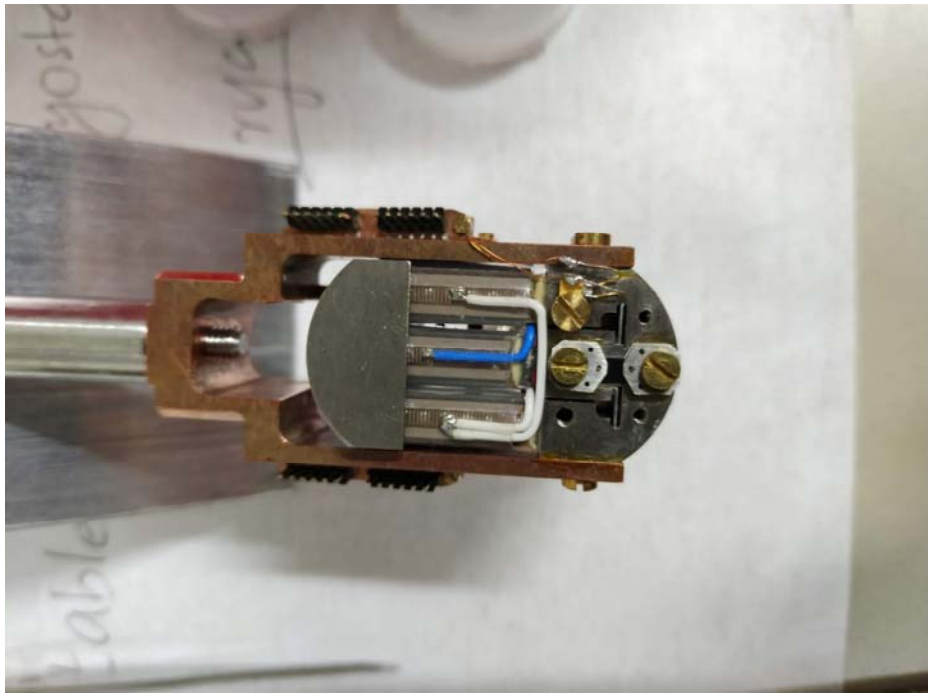
Effects of uniaxial strain on HgTe based topological materials

- We explore the possibility to introduce the topological phase transition by applying external uniaxial strain.



Mahler et al., Phys. Rev. X 9, 031034

Dresden:
Clifford Hicks



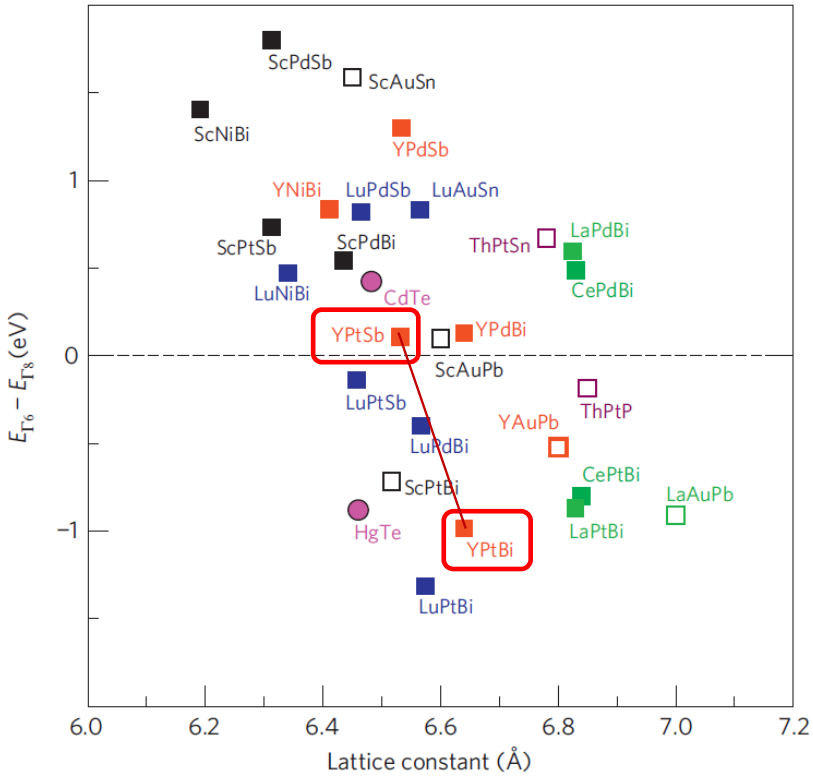
- A pressure cell mounted in a flow cryostat applies uniaxial strain at 3K.
- We perform low temperature transport experiments while applying strain.
- Raman spectroscopy setup allows to monitor the applied strain directly.

Molecular beam epitaxy of the topological superconductor YPtBi

- YPtBi is predicted to be a topological superconductor
- Goal: Investigate the topological superconductivity on epitaxial YPtBi thin films
- Idea: Lattice-matched YPtBi growth on KBr(001) by Sb-alloying

$YPt(Bi_xSb_{1-x})$
KBr Substrate

x > 10%: topological non-trivial
$x \approx 42\%$: matched to KBr

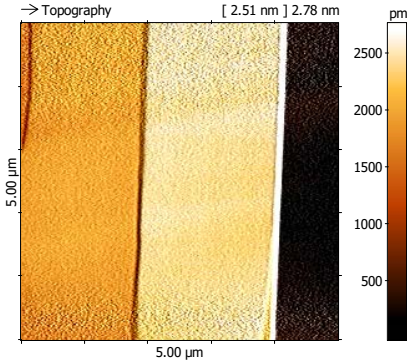


Nat. Mater. 9, 541 (2010)

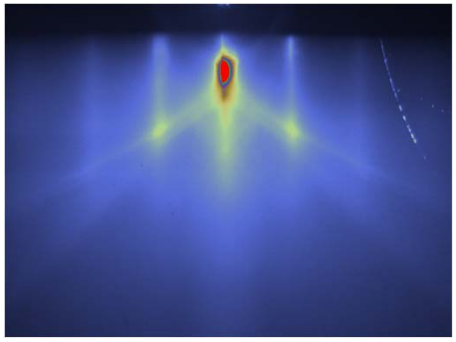
Dresden:
Claudia Felser
Anastasios Markou

Molecular beam epitaxy of the topological superconductor YPtBi

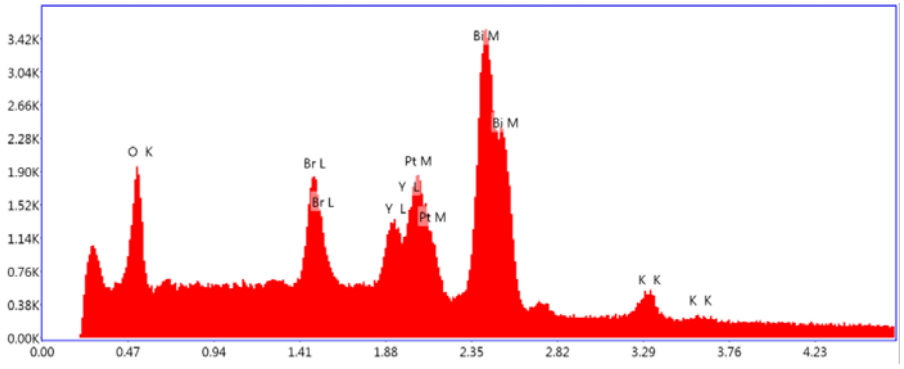
- YPtBi thin film growth on cleaved KBr(001) substrate



Micrometer-size wide terraces on cleaved KBr



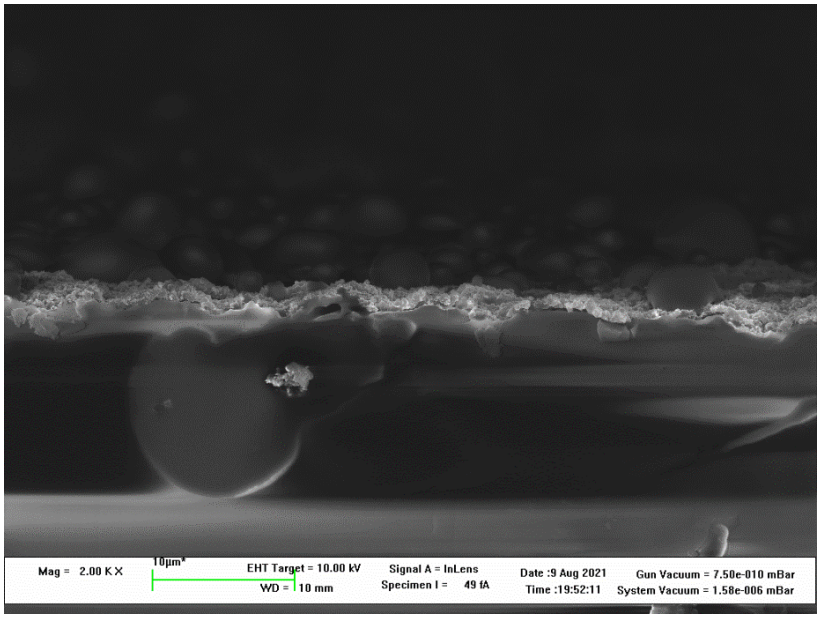
Streak RHEED pattern on cleaved KBr



Element	Atomic %
Y	8.3
Pt	8.1
Bi	28.2
K	15.9
Br	8.7
O	30.7

Compositional ratio of grown film is determined by EDX

- Alternative substrate for epitaxial YPtBi growth



- Chemical reaction between KBr and grown Y-Pt-Bi film
- Al_2O_3(0001) substrate is used to grow (111)-oriented YPtBi thin films