Pressure-induced Superconductivity in Topological Quantum Materials

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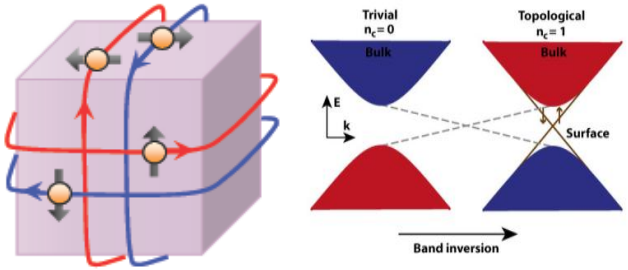
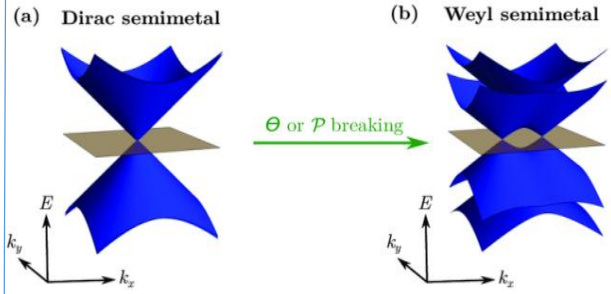
Topological Quantum Materials

Topological Insulator



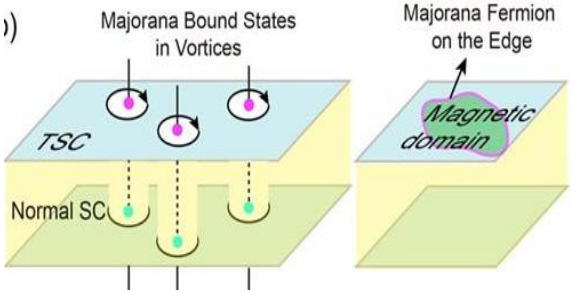
- Insulator in Bulk, conducting states on surface
- bulk band inversion
- Surface states in terms of linear band crossings (2D Dirac cone)
- Helical spin polarization
- robust to disorder

Topological Semimetal



- Linear band crossing at a Dirac point in bulk (3D Dirac cone)
- ultra-high mobility
- Non-saturating linear magnetoresistance

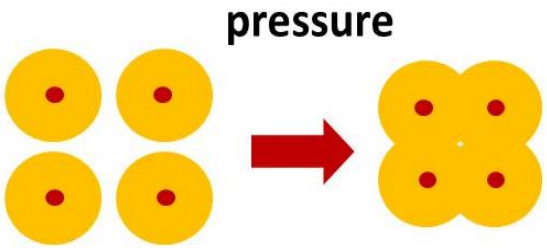
Topological Superconductor



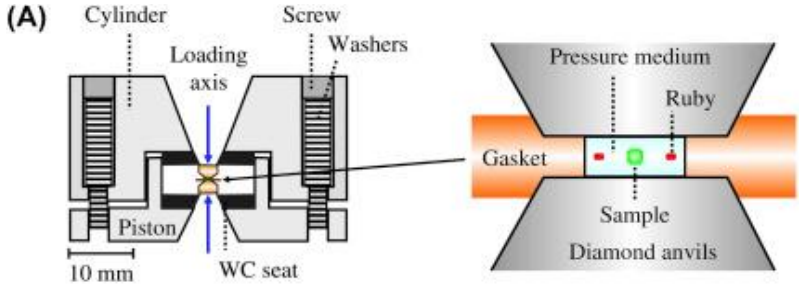
- Full superconducting pairing gap in bulk
- Gapless surface states /Majorana edge states
- platform for Topological Quantum Computation

Pressure as a tuning parameter

pressure effect ; shortening of atomic distance



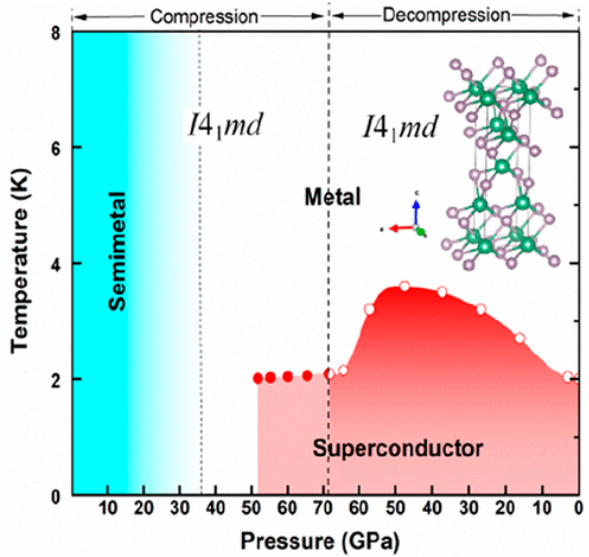
Diamond-anvil-cell (DAC)

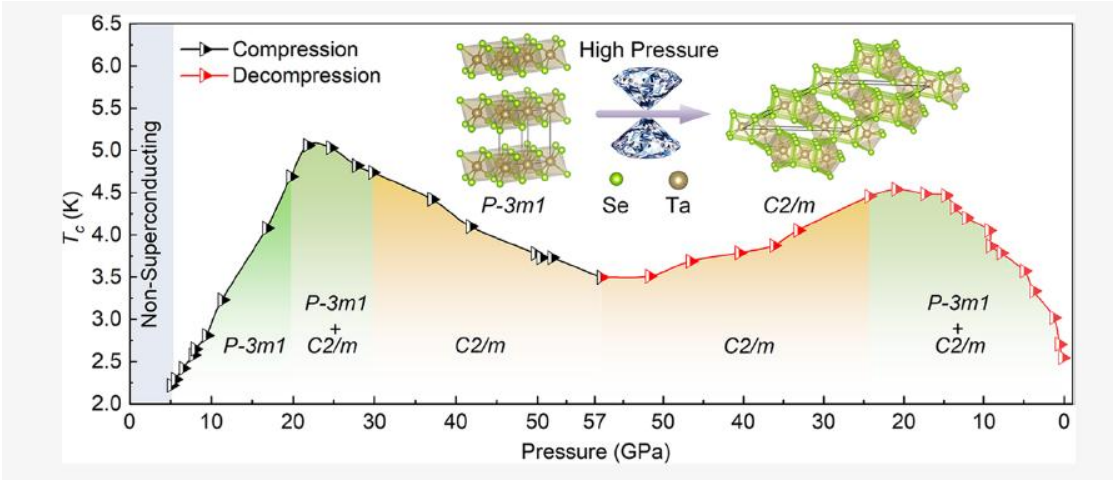


$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

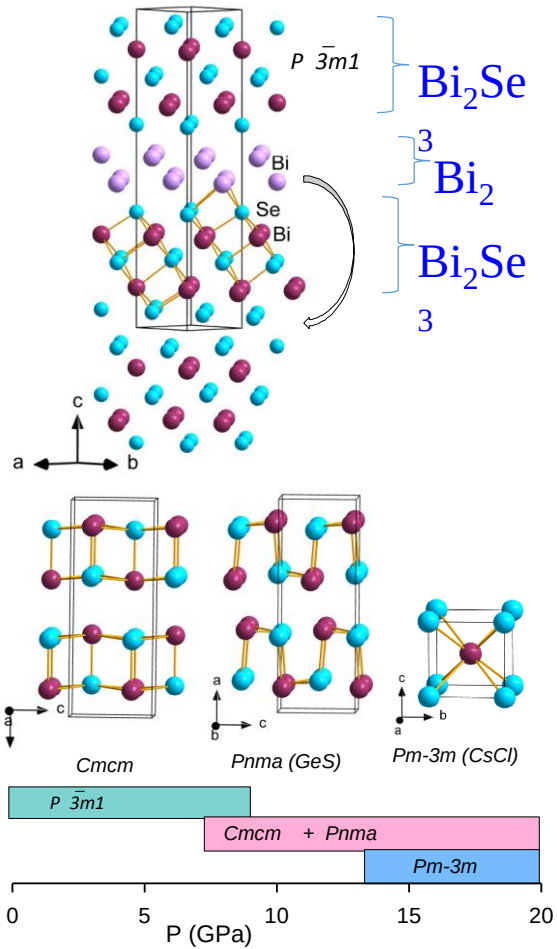
10^5 Pa = 1bar

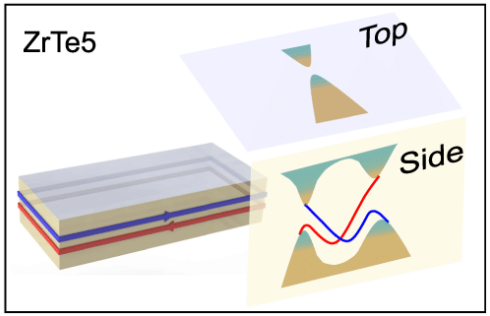
1 gigapascal (GPa) = 10 kbar





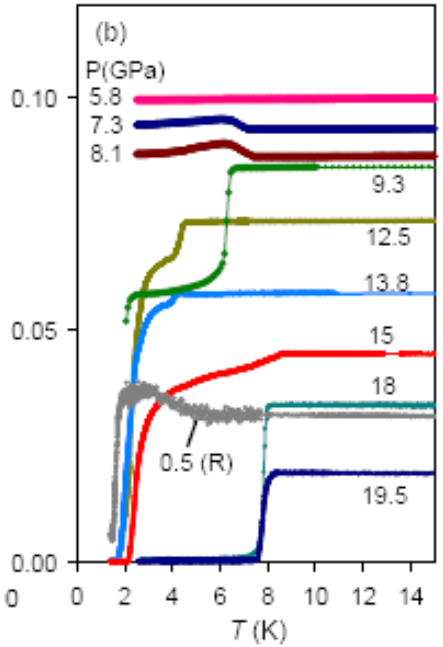
Weak Topological Insulator BiSe

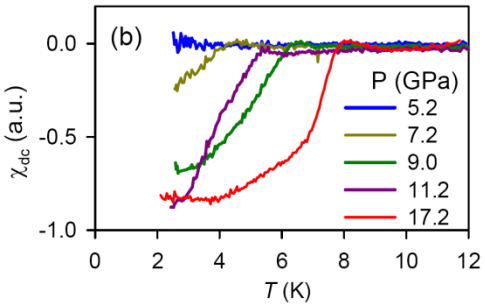




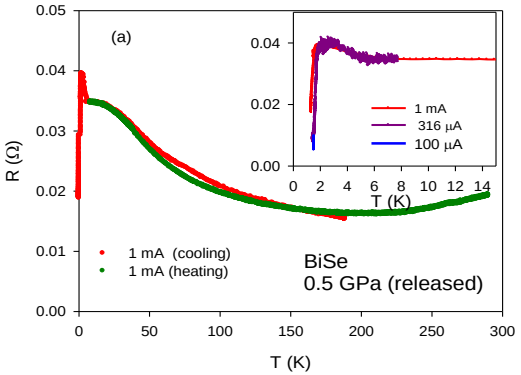
- BiSe is a natural superlattice of Bi2Se3,-Bi2- Bi2Se3 having a trigonal structure.
- surface states on the side surfaces with even no. of Dirac cones
- a total structural reconstruction above 8 GPa into SnSe-type orthorhombic structures, with energetically tangled mixed phases (Cmcm and Pnma).
- above 13 GPa, Orthorhombic -CsCl-type cubic phase transition

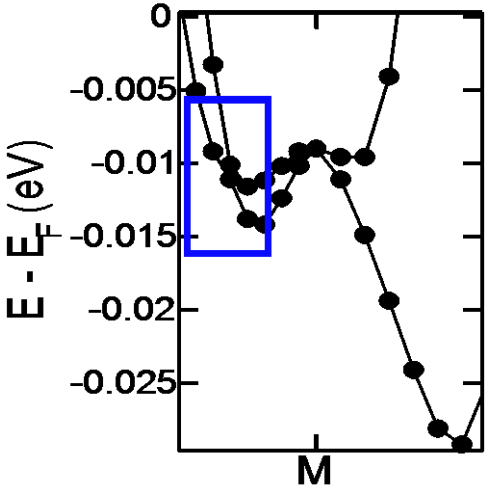
Pressure-induced Superconductivity and its persistence upon P-release

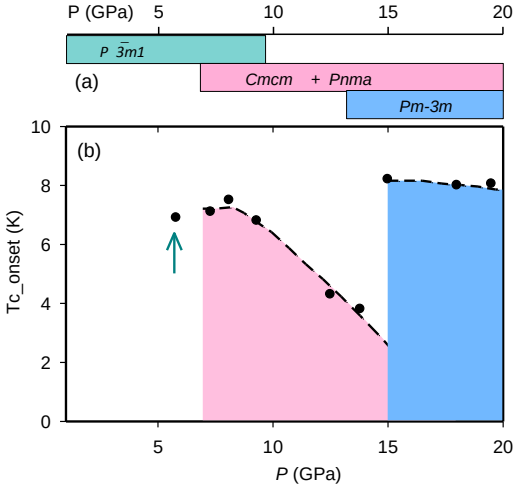




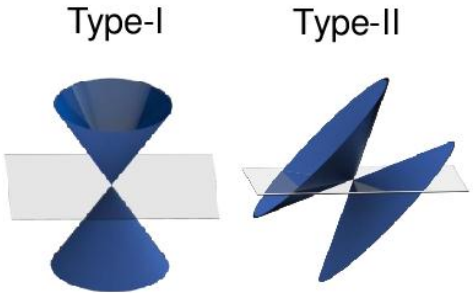
- P-induced SC above 6 GPa
- SC is preserved in the P-released sample with trigonal symmetry that supports Topological insulating state
- Cubic BiSe: candidate 3D Topological Superconductor!

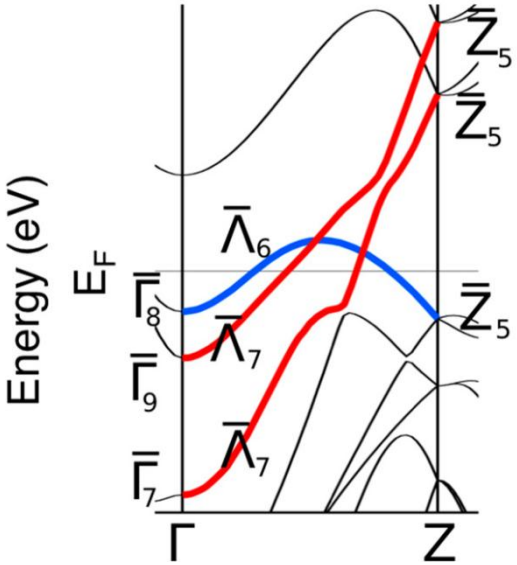




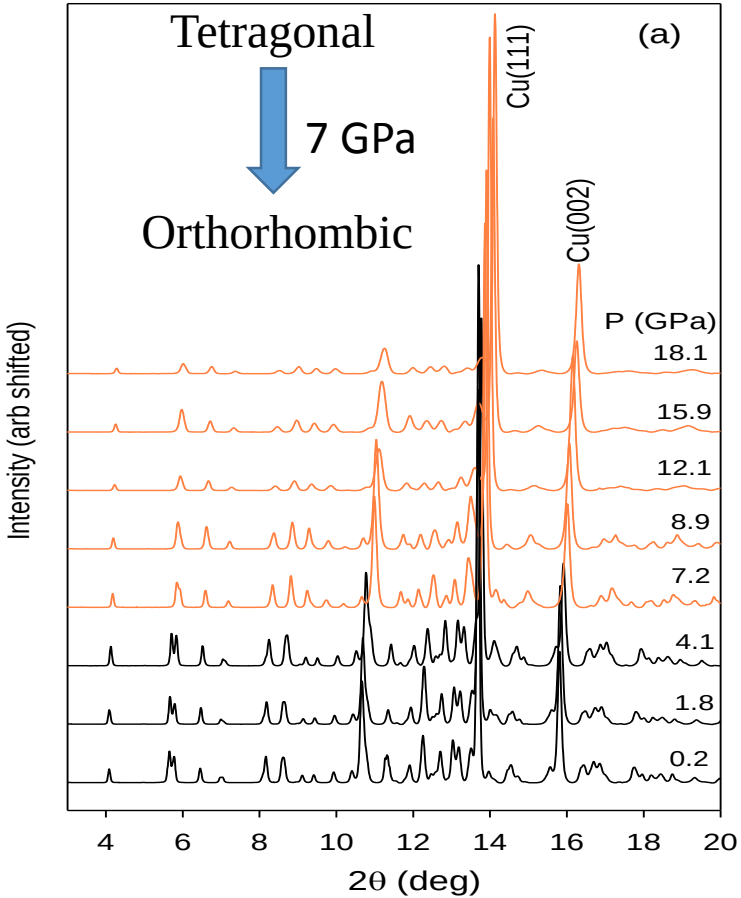


Type II Dirac semimetal candidate Ir_2In_8S

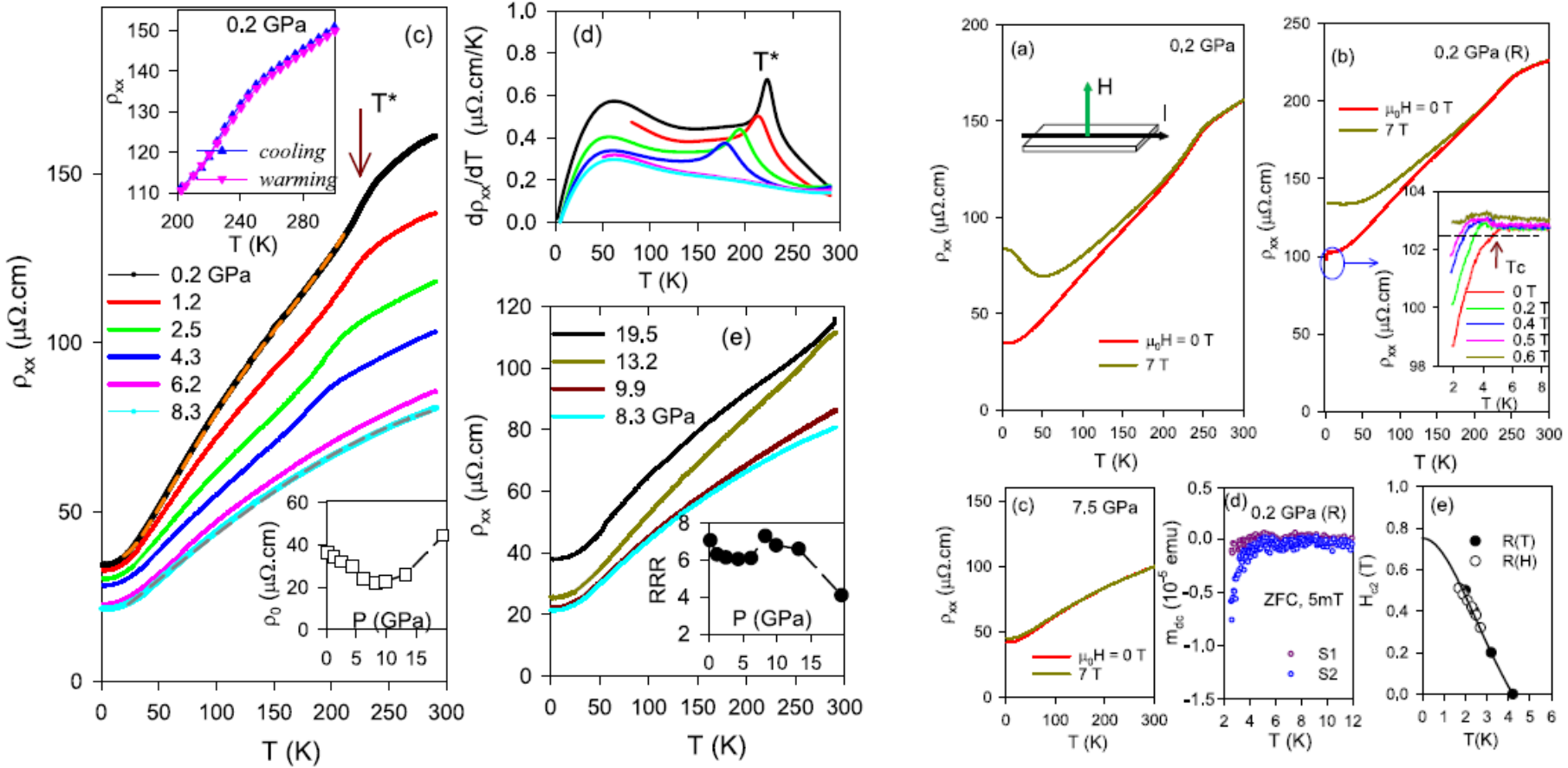




- Type II DSM exhibiting tilted Dirac cones
- two Dirac crossings at 25 and 40 meV above the Fermi level
- pressure-induced band broadening may shift the Fermi level upward towards the Dirac points by enhancing the carrier density and thus possibly exhibiting exotic transport signatures including superconductivity.



High pressure Resistivity measurements



Superconductivity upon P-release in presence of Large MR!!

References

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Acknowledgements

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Thank you