Anomalous angular magnetoresistance in PbSnSe - a 3D Dirac semimetal

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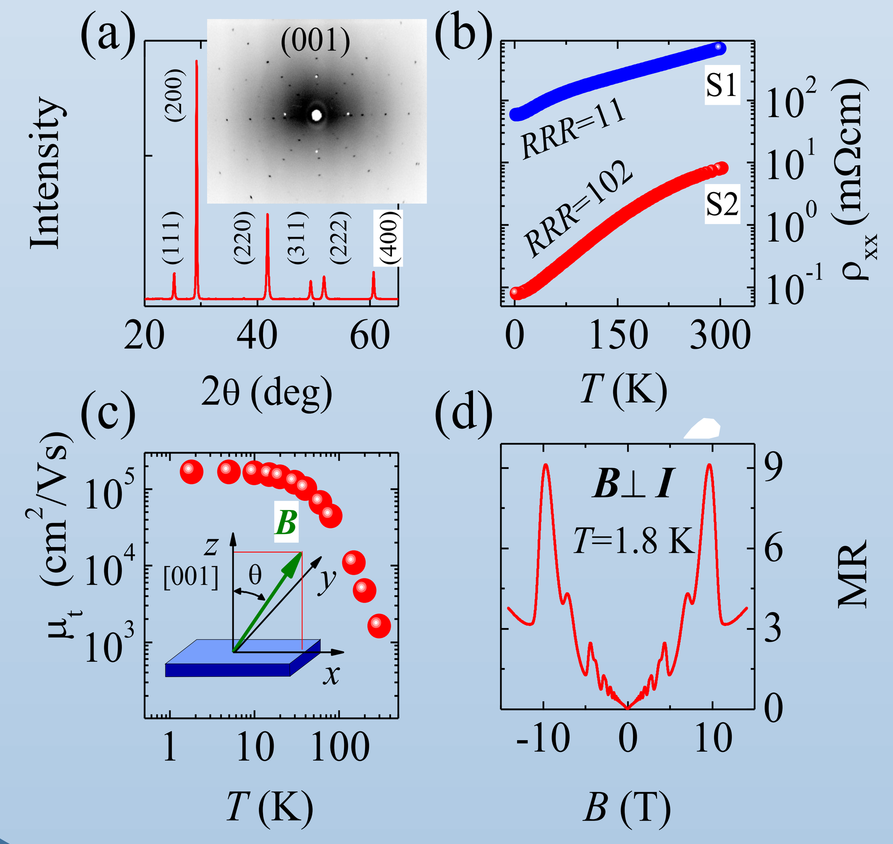
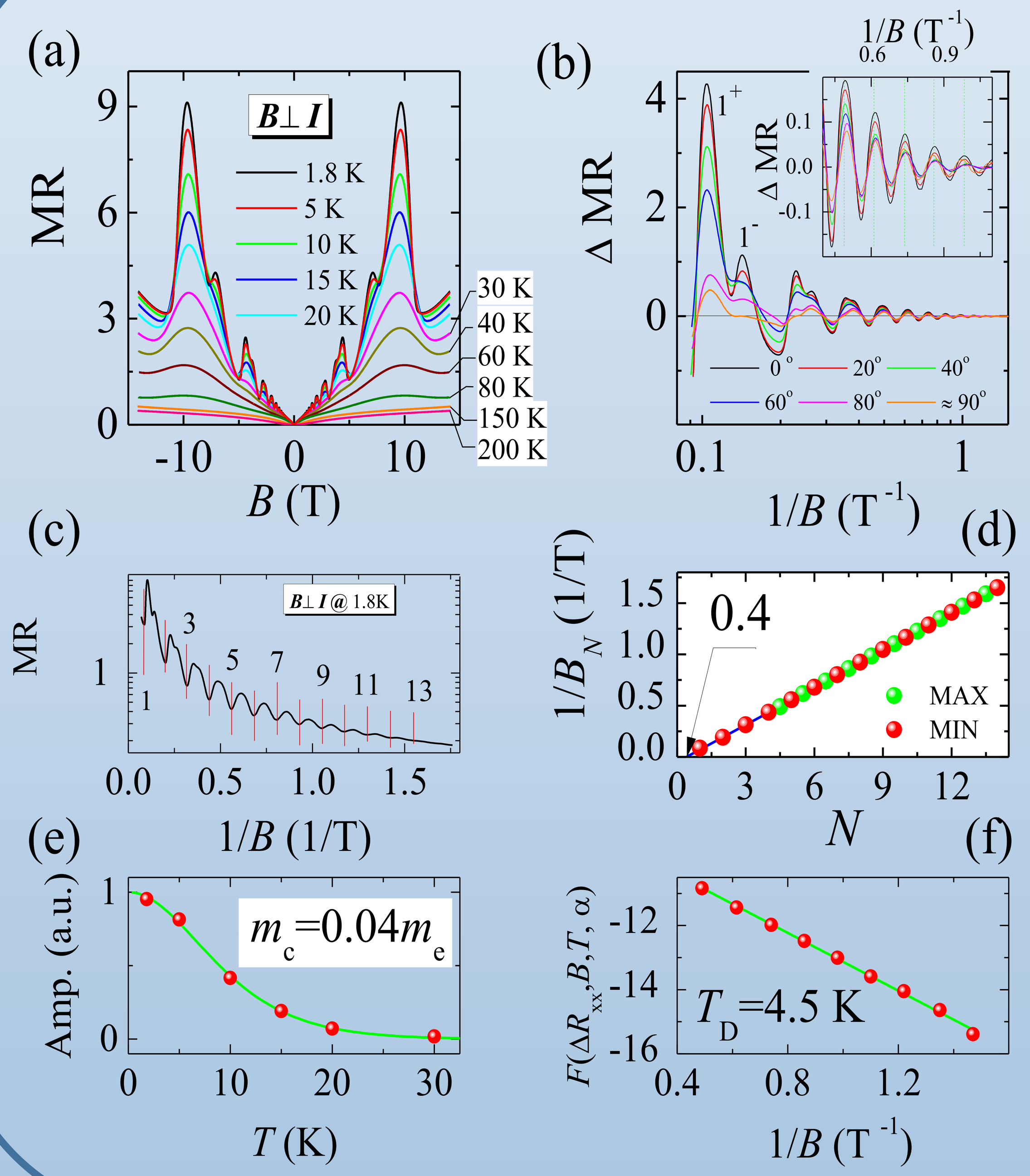
Single crystal characterisation

- Material $Pb_{1-x}Sn_xSe$ set to x=0.17
- Transition between an ordinary and a topological insulator
- Single crystals were produced by a melt growth method
- Annealed in Se vapour to reduce the bulk charge carriers and increase sample mobility



Shubnikov-de Haas oscillations



- Single frequency of the oscillations
- No angular dependence of the frequency
- Small effective mass $0.04m_e$
- Small Dingle temperature

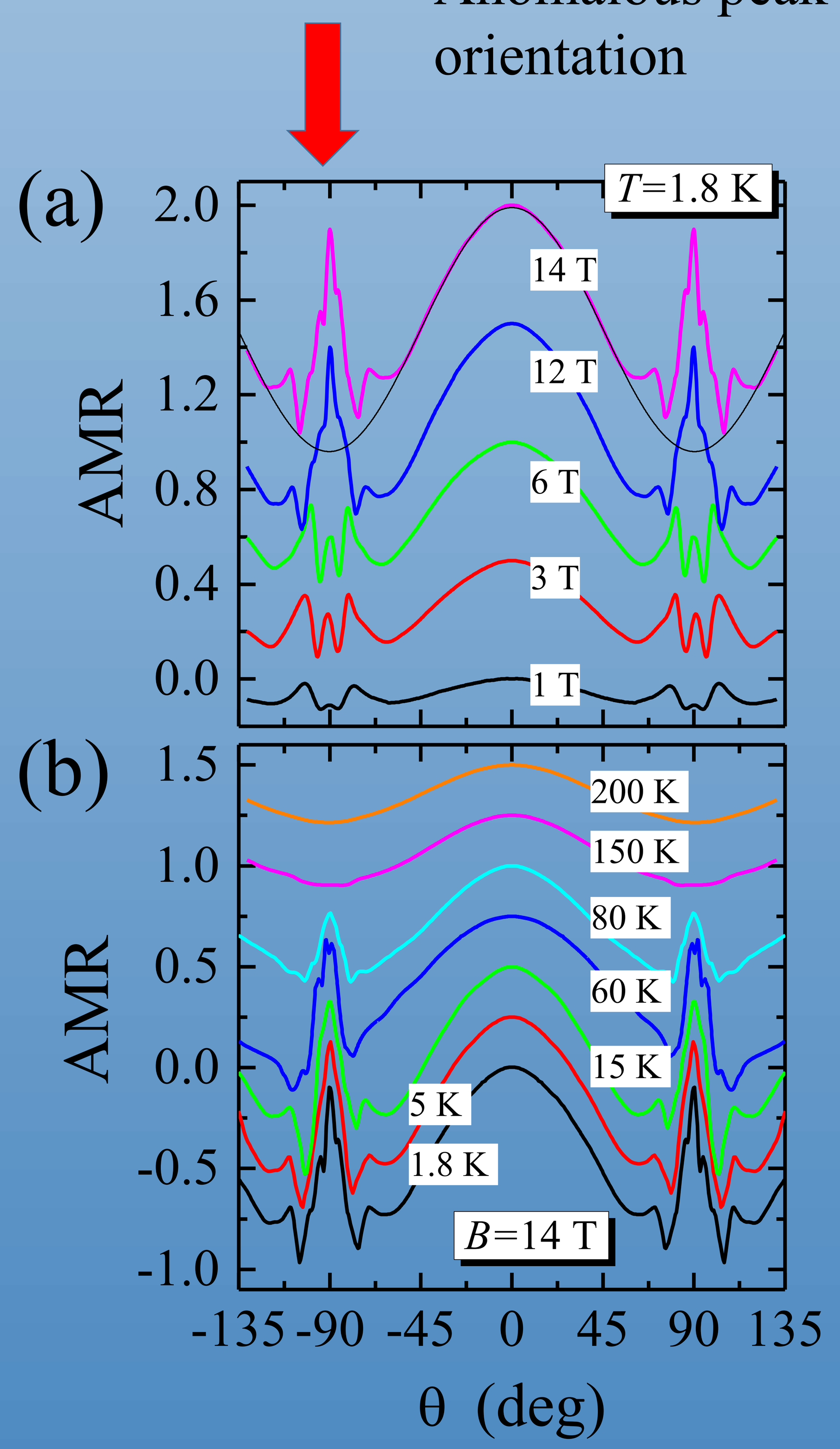
Landau level diagram

Landau level indexing diagram gives pi-Berry phase shift, confirming the 3D Dirac energy dispersion!

Angular Magnetoreistance

- Samples was rotated in the external magnetic field
- Rotation form TRANSVERSAL to LONGITUDINAL orientation

Anomalous peak in the longitudinal orientation

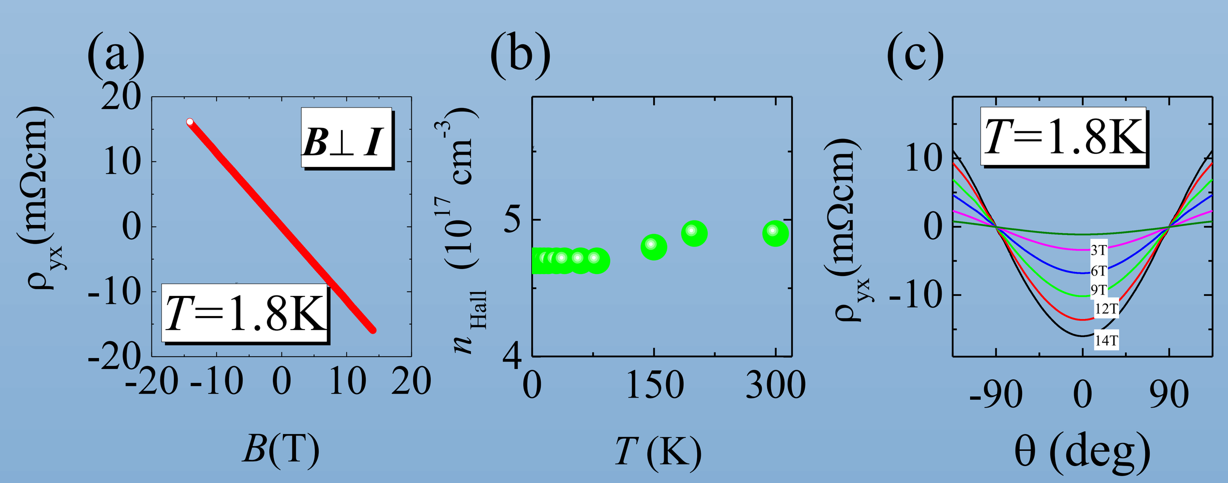


- Classically we do not expect MR in longitudinal direction
- **Chiral anomaly predicts negative MR**

- Our effect is related the Landau quantisation
- It becomes strong in the ultra quantum limit

- In the ultra quantum limit the system becomes effectively Q1D system, all degrees of freedom except k_z are quenched
- Elevated temperature destroys the effect of the anomalous longitudinal magnetoresistance

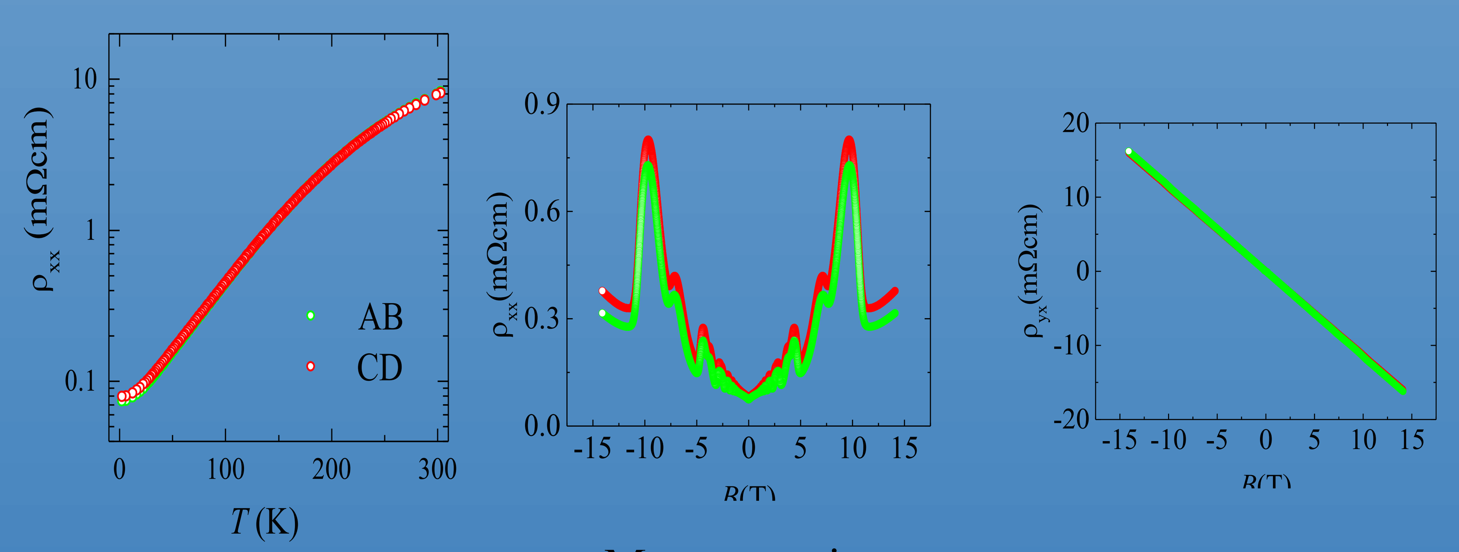
Angular dependence of Hall resistivity



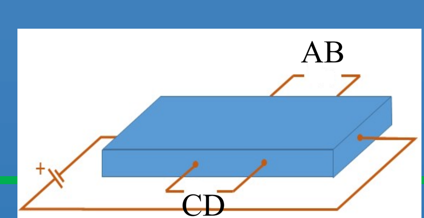
- Usual angular dependence the Hall signal
- No anomaly at 90 deg
- Linear field dependence - single type of charge carriers

Sample homogeneity

Measured sample has shown an excellent transport homogeneity



- Temperature dependence of resistivity on the two side of the sample
- Magnetoresistance on the two side of the sample
- Hall resistivity on the two side of the sample



Conclusion

- The sample is of high quality and homogeneity
- Angular magnetoresistance has shown an unusual peak in the longitudinal orientation
- The peak becomes strong in the ultra quantum limit when the system becomes effectively Q1D system
- Studied system is a 3D Dirac semimetal (metal)
- Effects of the chiral anomaly would be expected
- Recent theoretical work of *Goswami et al.* [I] could give a clue to the answer of this phenomena
- The neutral impurity short range scattering plus the Q1D metallic state due to the high magnetic field could lead to an increase of the longitudinal resistivity. [II]

I. P. Goswami, J. H. Pixley, and S. Das Sarma, Phys. Rev. B 92, 075205 (2015).
II. Mario Novak, Kouji Segawa, Henry Legg, Achim Rosch, and Yoichi Ando, *to be published.*

- **This presentationhas been fully supported by Croatian Science Foundation under the project (6216).**