Twofold symmetry of *c*-axis resistivity in topological kagome superconductor CsV_3Sb_5 with in-plane rotating magnetic field

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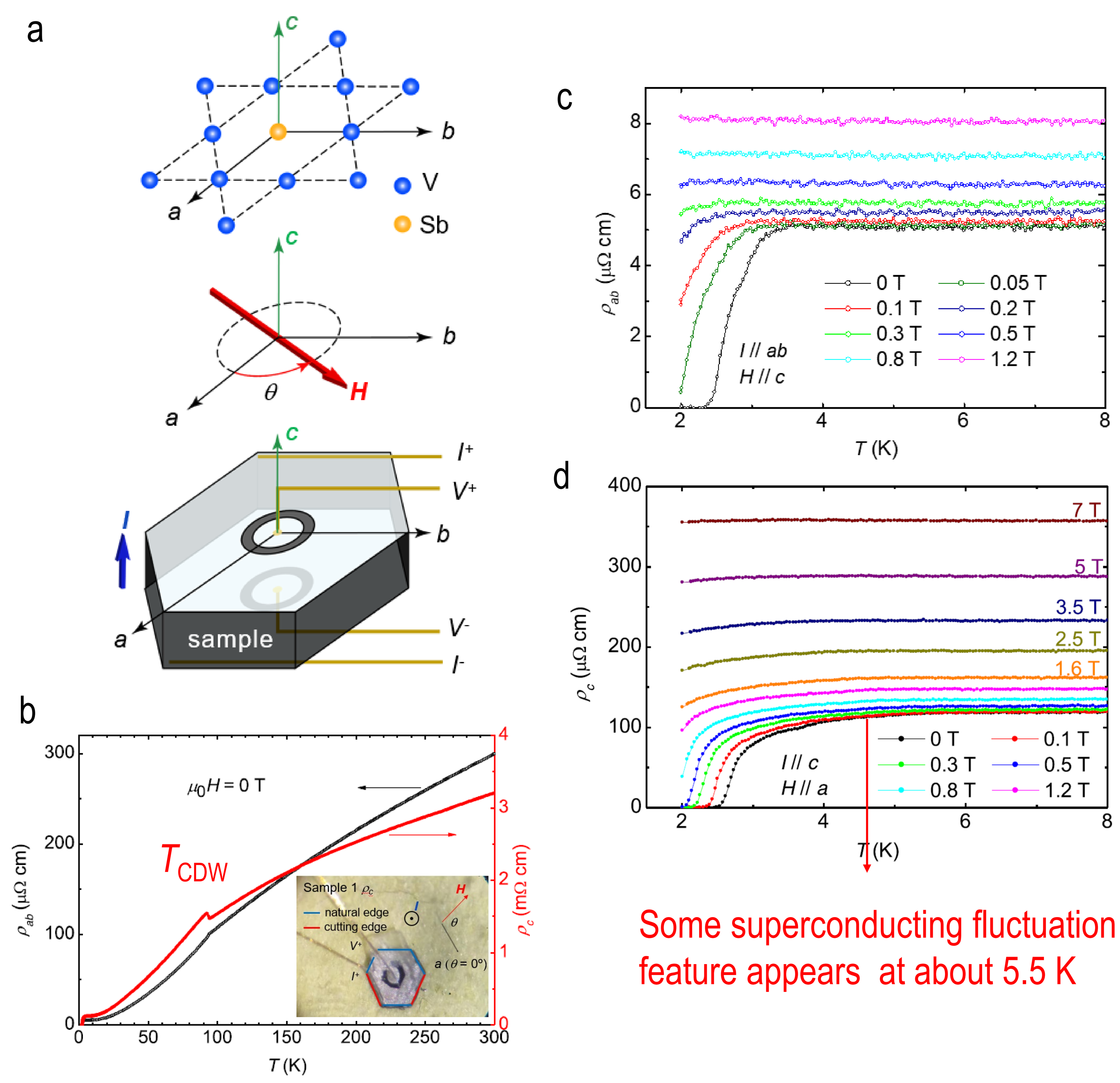
Abstract: Materials with a kagome lattice structure can host a rich variety of exotic states including spin liquid, spin density wave, charge density wave and superconductivity. Recently, a new family of kagome metals AV_3Sb_5 (*A* = K, Rb, or Cs) has been discovered, which attracted tremendous attention. The nematic electronic state breaks the symmetry of the crystal structure in many strongly correlated electron systems, including cuprates, iron-based superconductors. Superconductivity with twofold symmetry seems to be a common feature in topological superconductors, which is explained theoretically as a consequence of superconducting order parameter with odd parity. We measured the *c*-axis resistivity (ρ_c) with in-plane rotating magnetic field, we observe a twofold rotational symmetry of angular dependent $\rho_c(\theta)$ both in the superconducting state and the normal state of the topological kagome metal CsV_3Sb_5. In addition, these two kinds of orders are orthogonal to each other in terms of the field direction of the minimum resistivity. These observations will shed new light in the study of this fascinating kagome and topological material.

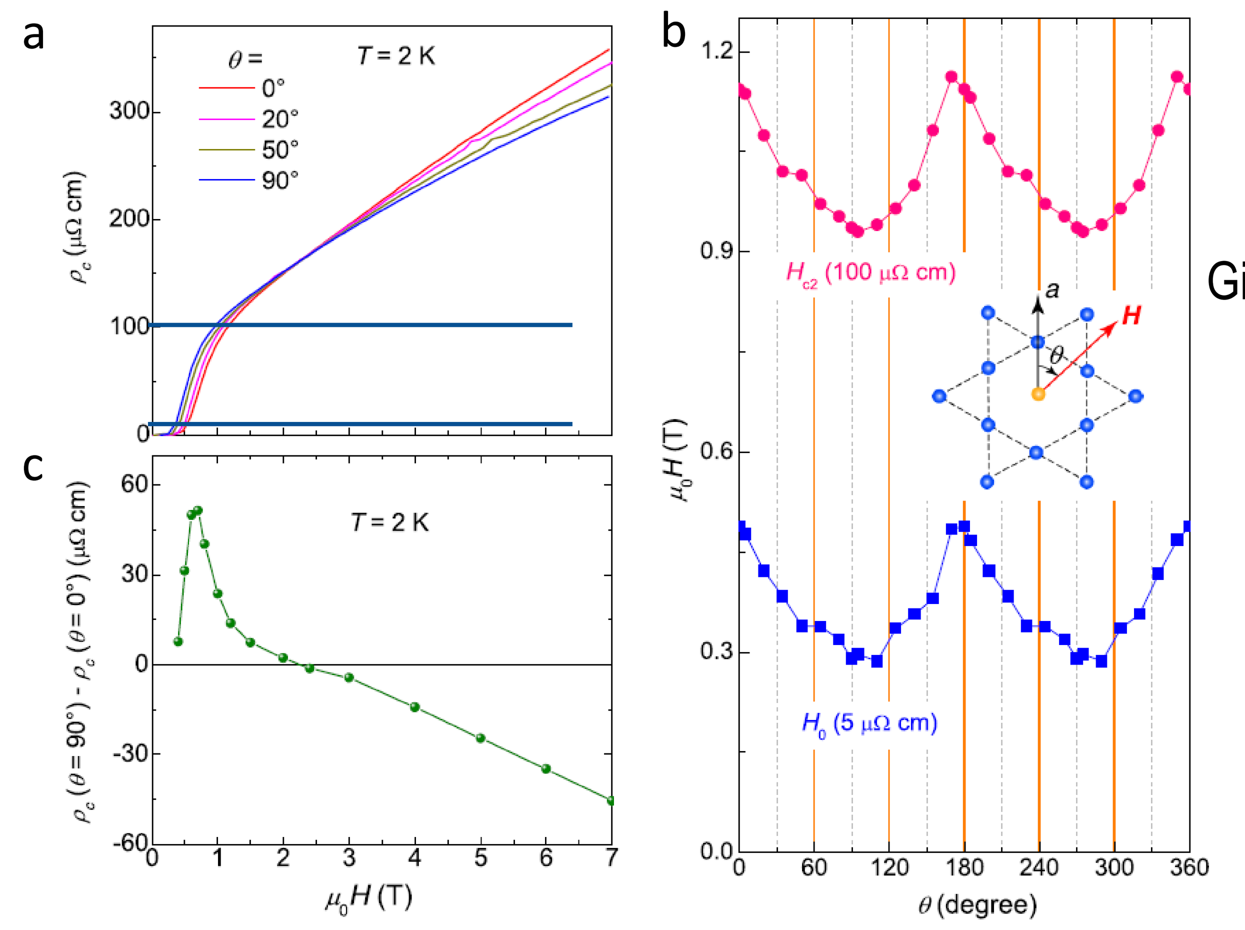
Difference between ρ_c and ρ_{ab}



Some superconducting fluctuation feature appears at about 5.5 K

The advantage of using a Corbino-shape-like electrode configuration is that a major part of the current is flowing along the *c*-axis, and thus is always perpendicular to the in-plane rotating magnetic field. This would avoid the undesired angle dependence of the in-plane resistivity due to the flux flow if the current were applied along ab-plane.

Magnetic-field induced phase reverse of $\rho_c(\theta)$ curves with twofold symmetry



Pippard equation:

$$\xi = \frac{\hbar v_F}{\pi \Delta}$$

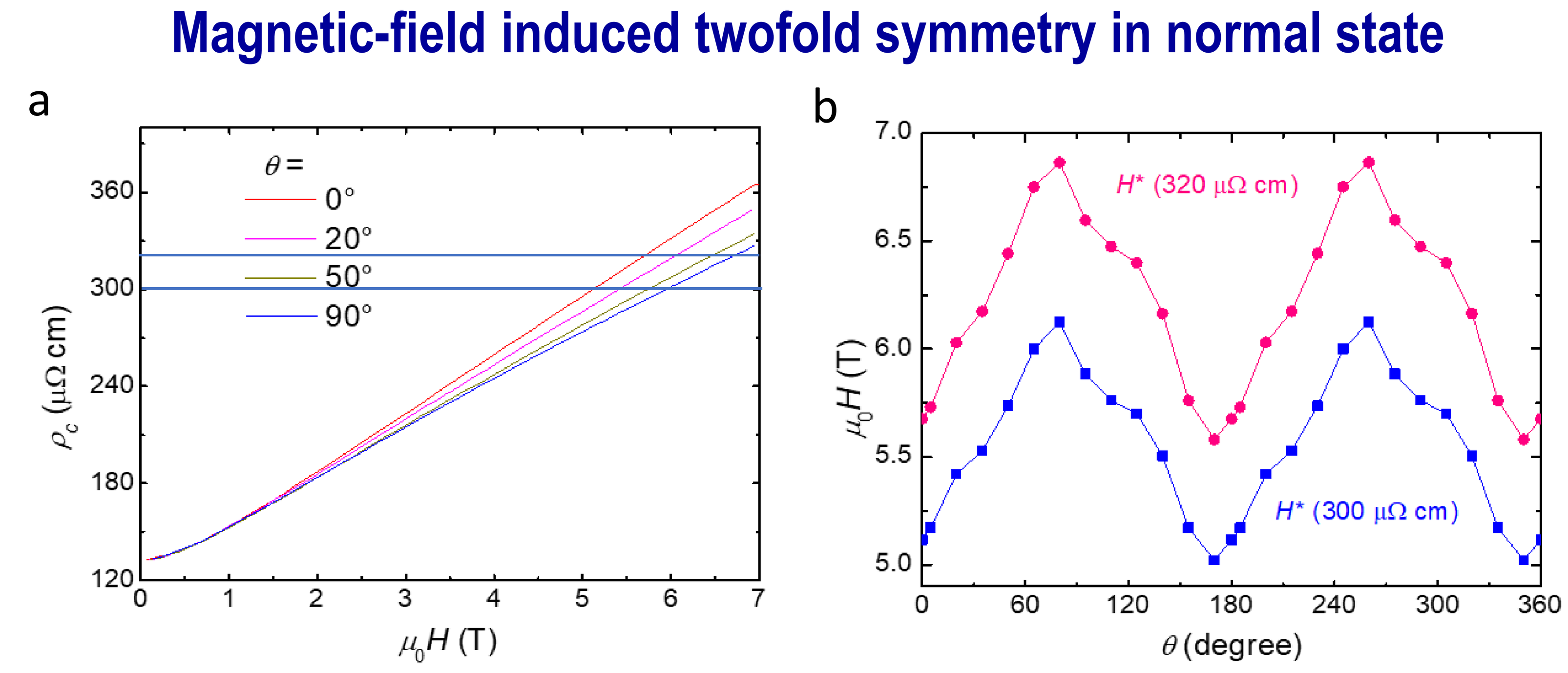
Ginzburg-Landa theory:

$$H_{c2} = \frac{\Phi_0 \pi}{2\hbar^2 v_F^2}\Delta^2$$

$$H_{c2} \propto \frac{\Delta^2}{v_F^2}$$

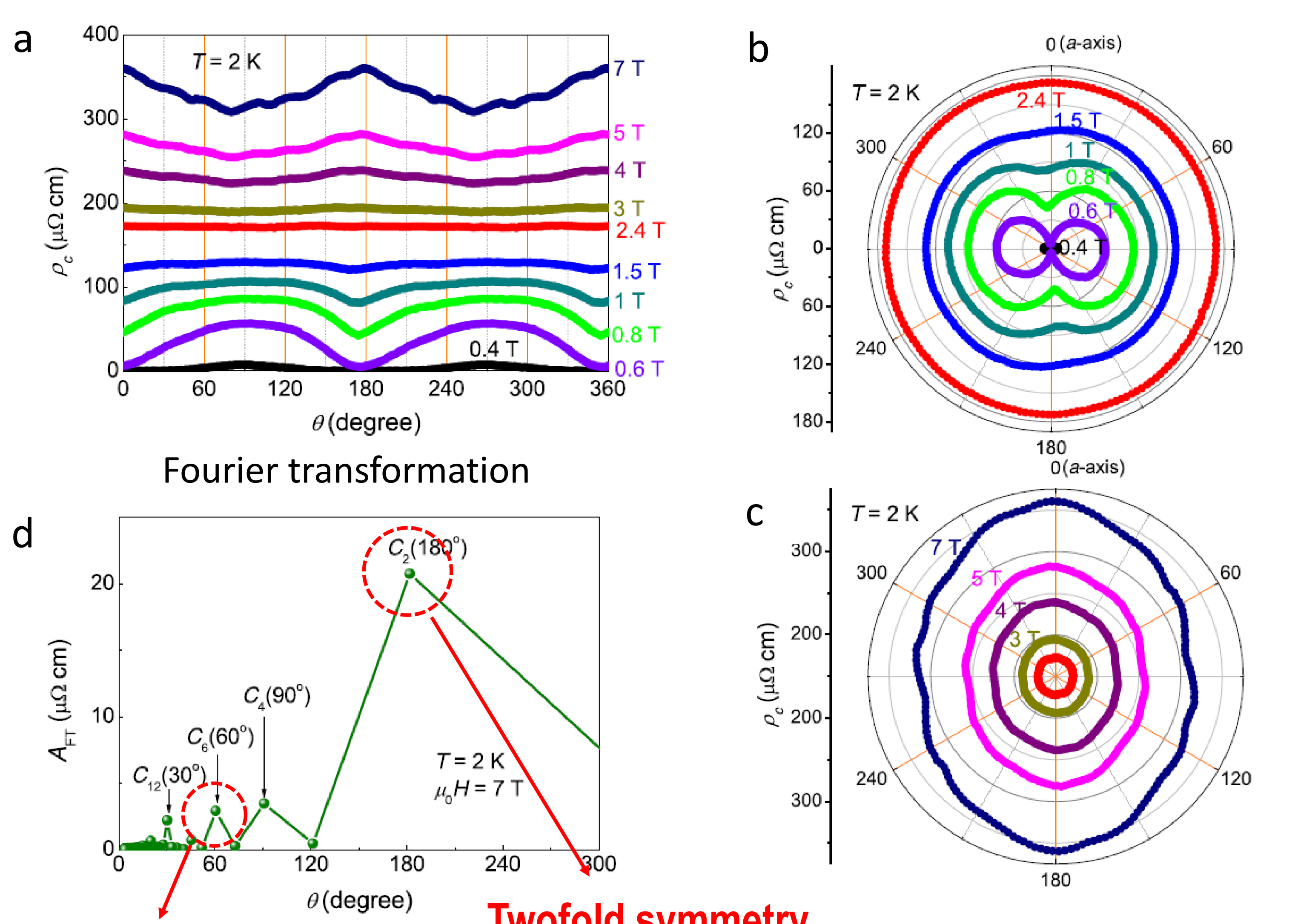
twofold feature of the SC gap

Magnetic-field induced twofold symmetry in normal state



In the presence of a magnetic field, the mobile electrons will possess a circular momentum in the plane perpendicular to the field direction. The *c*-axis resistivity should contain the contribution of the in-plane electronic states or the in-plane mobility component along the direction perpendicular to the magnetic field.

Magnetic field evolution of the twofold symmetry



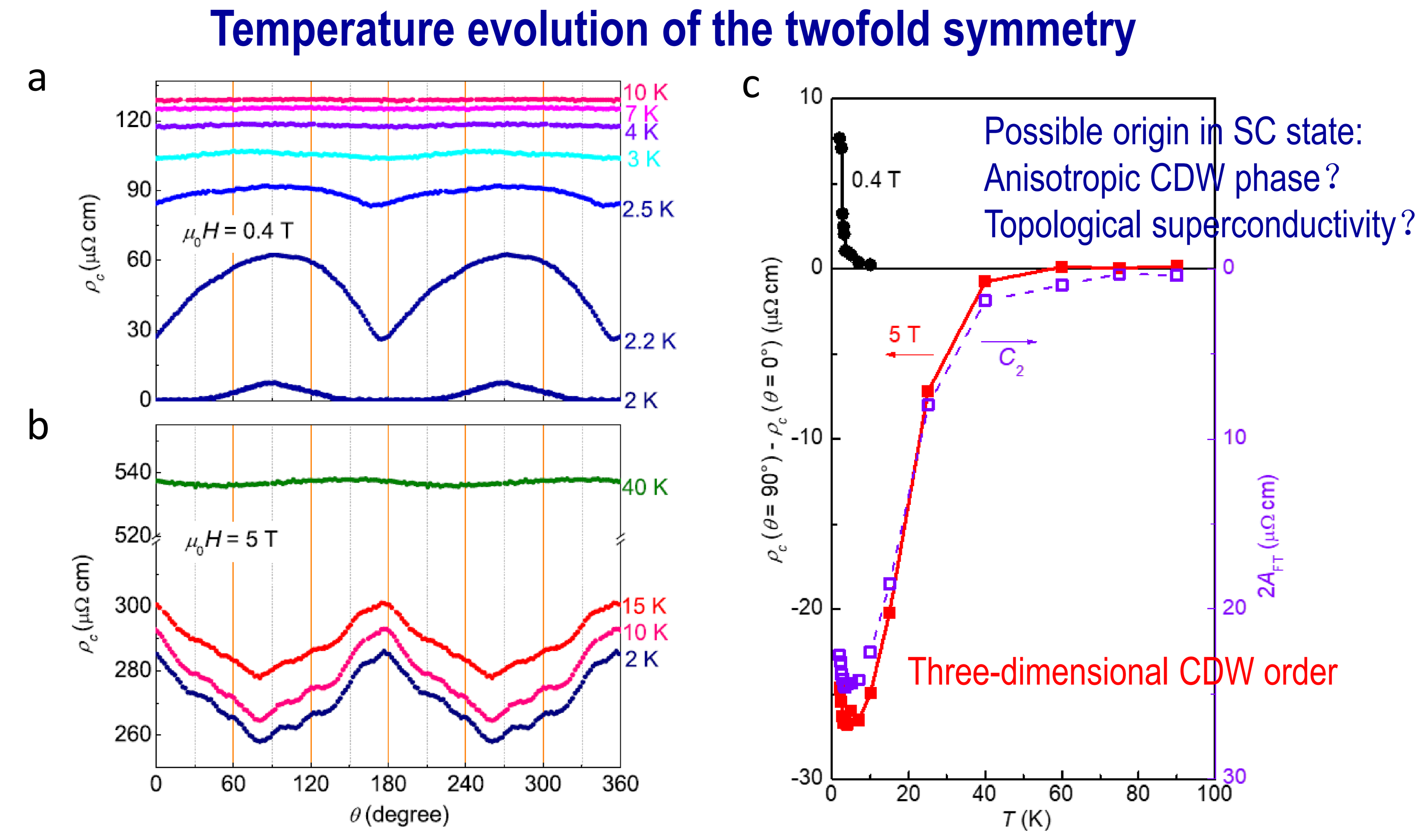
Fourier transformation

Six-fold symmetry of the lattice

Twofold symmetry

The two kinds of $\rho_c(\theta)$ curves below and above 2.4 T are orthogonal to each other in terms of the field direction of the extremum resistivity.

Temperature evolution of the twofold symmetry



Possible origin in SC state:
Anisotropic CDW phase?
Topological superconductivity?

Three-dimensional CDW order

In 3D CDW configuration, a π phase shift between neighboured V−Sb kagome layers, in addition to the inter-layer coupling between the neighboured layers lower the six-fold symmetry to a twofold in the normal state.

Conclusions

- A twofold symmetry of superconductivity is observed in the superconducting state in CsV_3Sb_5;
- A unique twofold symmetric resistivity with in-plane magnetic field is observed above T_c, together shown is a threefold or sixfold resistivity oscillation above T_c;
- These two orders are orthogonal to each other in terms of the field direction of the minimum resistivity;
- Our results shed new light in understanding non-trivial physical properties of CsV_3Sb_5.

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