Layer-Dependent Superconductivity in Ta-doped Kagome Superconductor $Cs(V_{0.86}Ta_{0.14})_3Sb_5$

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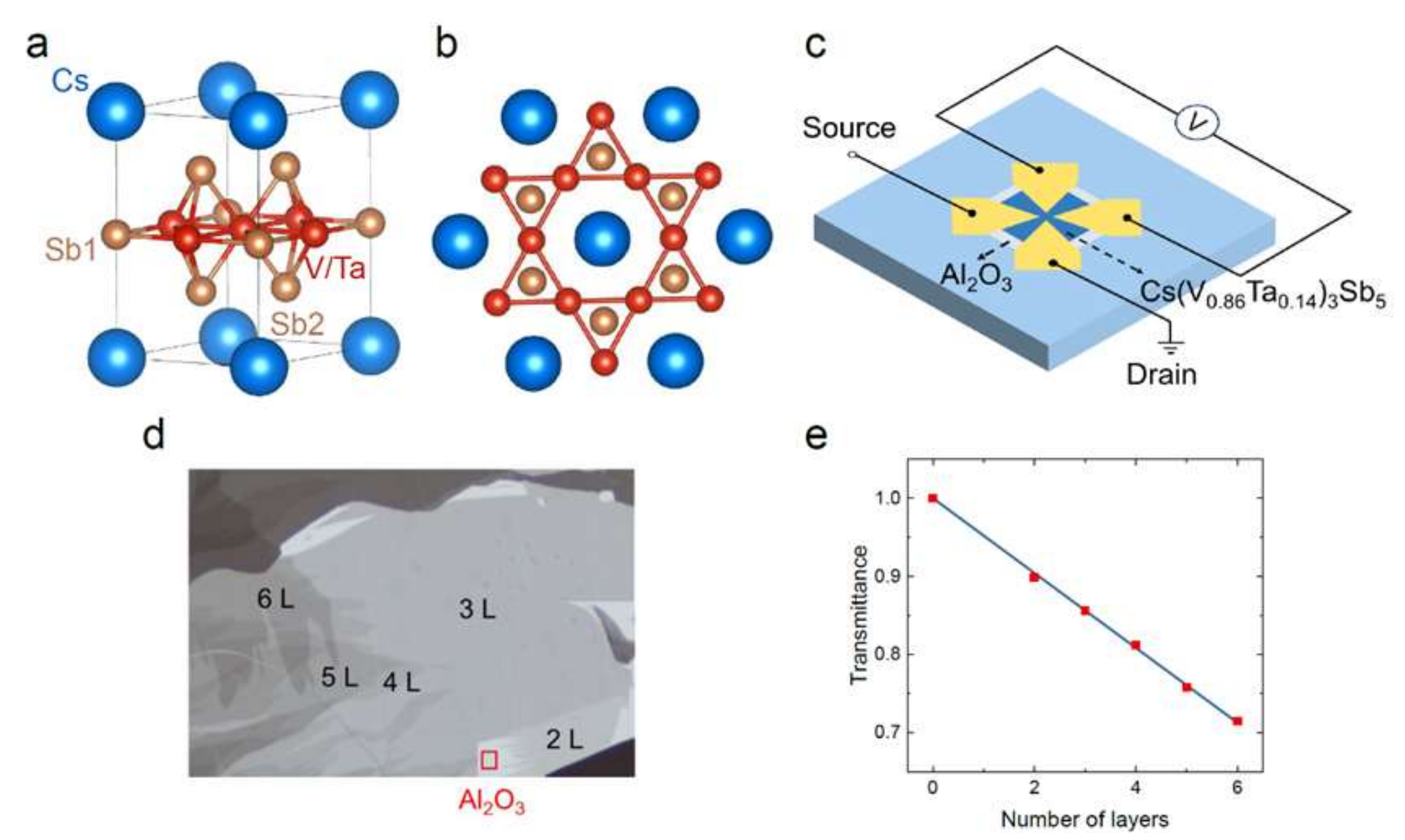
Introduction

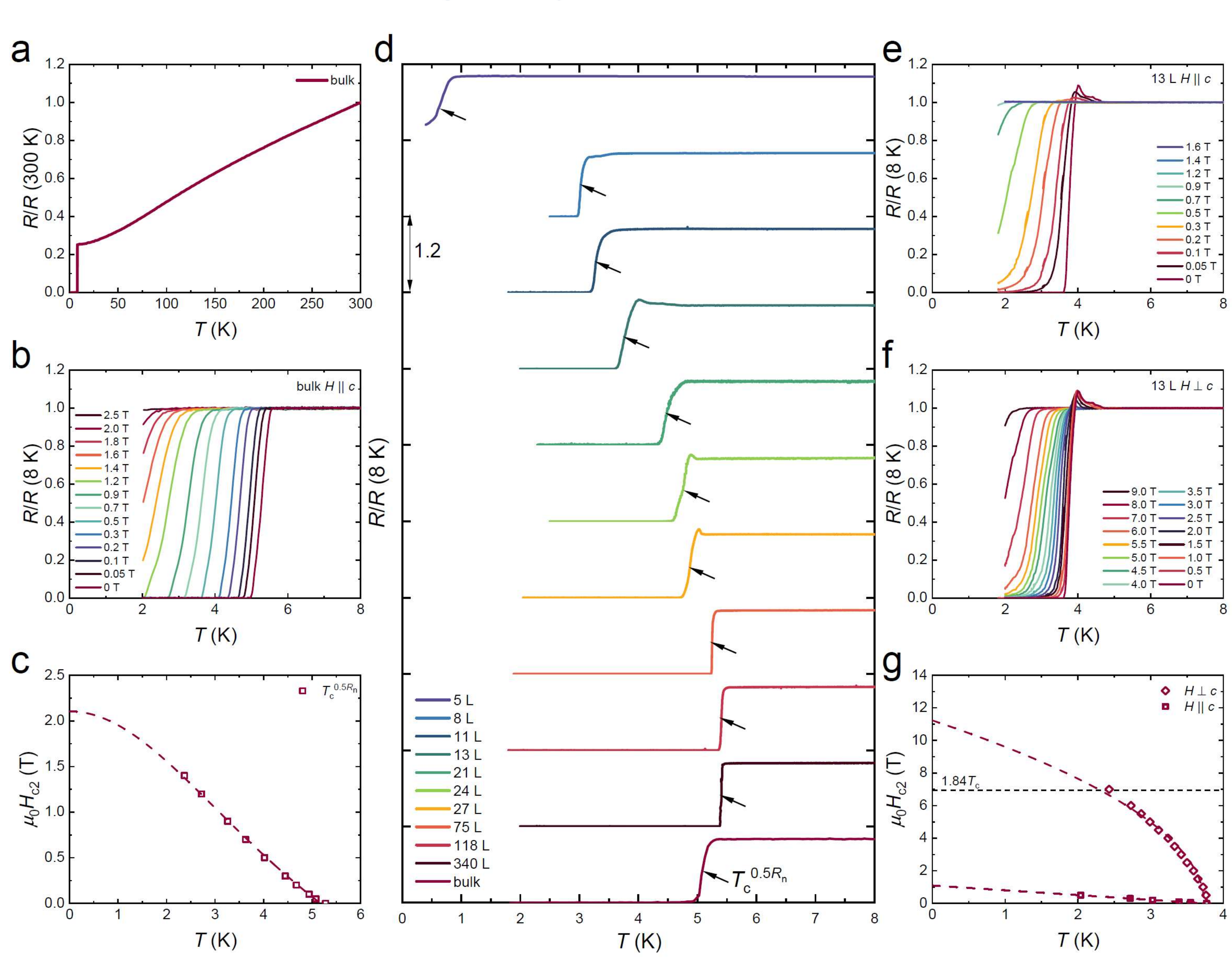
Exploring the property of layered superconductors approaching 2D limit is essential for clarifying comprehensive electronic correlation and uncovering intrinsic superconductivity mechanism [1-3]. Kagome materials AV_3Sb_5 (A = Cs, Rb, K) have emerged as a focal point of condensed matter physics due to the intricate interplay between possible unconventional superconductivity, charge density wave (CDW) order and nematicity. However, the competition between superconductivity and CDW obscures the intrinsic superconducting ground state [4-7]. Here, we report the layer-dependent two-dimensional superconductivity in $Cs(V_{0.86}Ta_{0.14})_3Sb_5$ thin flakes, where the doping of tantalum atoms completely suppresses the CDW order. Our work characterizes the emergence of 2D superconductivity upon dimensional reduction in the absence of CDW, thereby providing critical insights into the intrinsic superconducting mechanism of kagome metal.

Structure and exfoliation of $Cs(V_{0.86}Ta_{0.14})_3Sb_5$ thin flakes



- ☐ Ta atoms occupy the V sites that provide **an effective in-plane negative pressure**
- ☐ **The Al_2O_3 - assisted mechanical exfoliated method**
- ☐ The cold-welded indium method and evaporated Cr/Au method

Electrical transport measurements of $Cs(V_{0.86}Ta_{0.14})_3Sb_5$ bulk single crystal and thin flakes

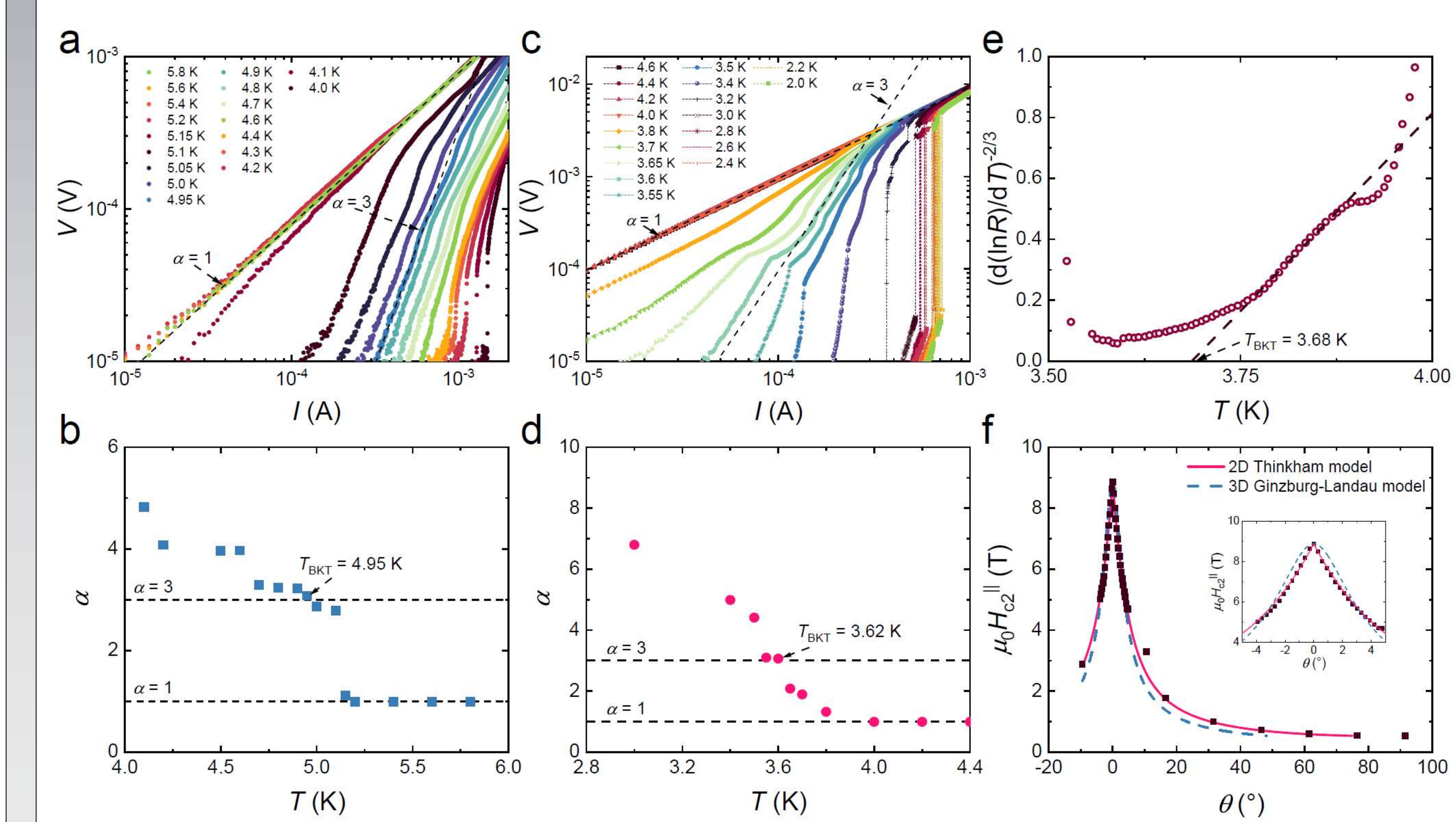


- **The single crystal:** **no CDW transition** and T_c = 5.16 K
- **The thin flakes:** **T_c slightly increases then decreases**
- **For 13 L sample:**

  The high anisotropy of upper critical field

  The in-plane upper critical field **exceeds Pauli limit**

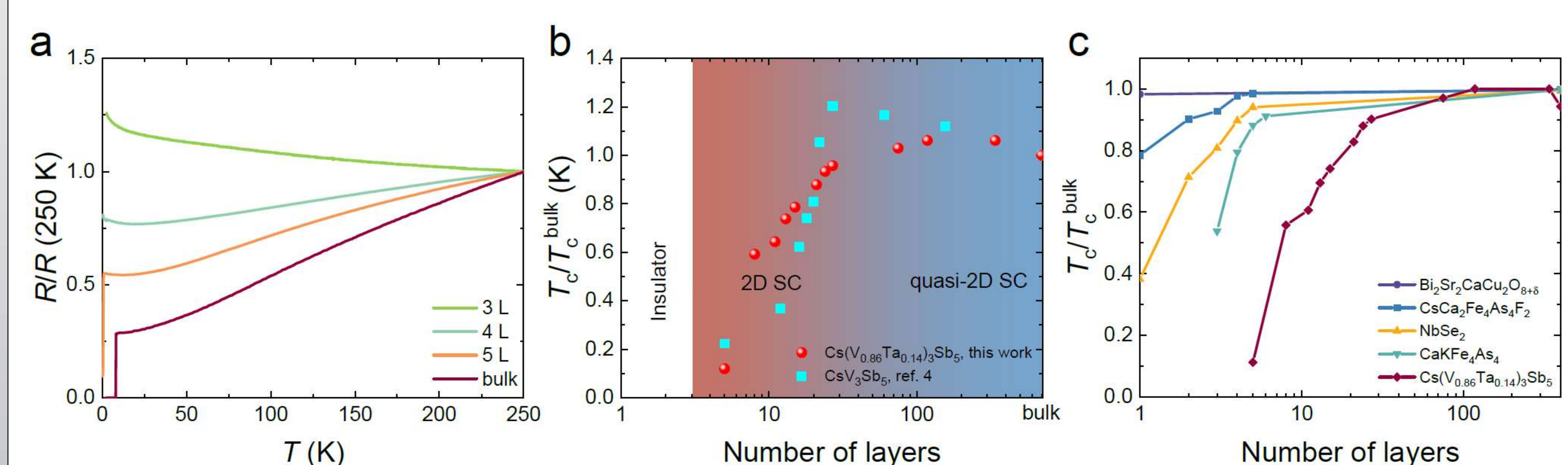
The 2D superconductivity of $Cs(V_{0.86}Ta_{0.14})_3Sb_5$ thin flakes



- ☐ Both of 35 L and 13 L sample show **BKT transition**
- ☐ The angle-dependent upper critical field fits **2D Tinkham model** in 13 L sample

2D superconductivity

Thickness-dependent resistance and phase diagram of $Cs(V_{0.86}Ta_{0.14})_3Sb_5$



- Below 5 L, the **metal-insulator transition** emerges
- Compared to CsV_3b_5 ➡ Overall similar, but **with differences in details**
- **More significant dimensional effect**

Summary

- ➢ Successfully fabricated $Cs(V_{0.86}Ta_{0.14})_3Sb_5$ thin flakes and demonstrated robust 2D superconductivity down to the few-layer limit.
- ➢ Established a comprehensive layer-dependent phase diagram and identified the dominant factor governing dimensional reduction in kagome superconductors.
- ➢ Provided a solid experimental foundation for future theoretical frameworks of unconventional superconductivity in kagome materials.

Reference

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