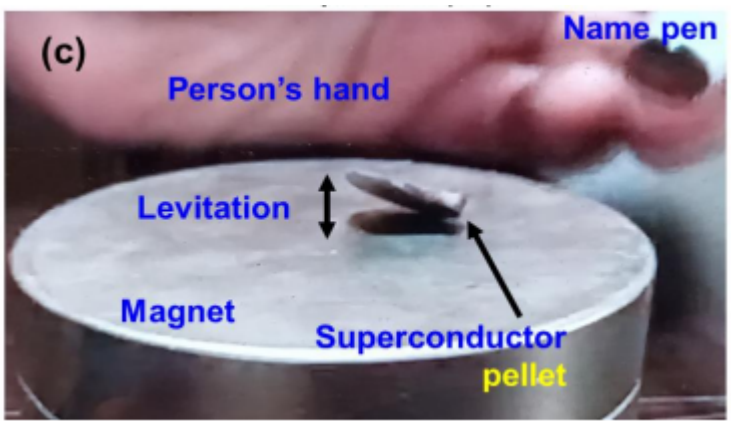
LK-99 isn’t a superconductor

Dan Garisto, Nature 620, 705-706 (2023)



Initial claims

Condensed Matter > Superconductivity

[Submitted on 22 Jul 2023]

The First Room-Temperature Ambient-Pressure Superconductor

Sukbae Lee, Ji-Hoon Kim, Young-Wan Kwon

For the first time in the world, we succeeded in synthesizing the room-temperature superconductor ($T_c \geq 400$ K, 127°C) working at ambient pressure with a modified lead-apatite (LK-99) structure. The superconductivity of LK-99 is proved with the Critical temperature (T_c), Zero-resistivity, Critical current (I_c), Critical magnetic field (H_c), and the Meissner effect. The superconductivity of LK-99 originates from minute structural distortion by a slight volume shrinkage (0.48 %), not by external factors such as temperature and pressure. The shrinkage is caused by Cu^{2+} substitution of Pb^{2+}(2) ions in the insulating network of Pb(2)-phosphate and it generates the stress. It concurrently transfers to Pb(1) of the cylindrical column resulting in distortion of the cylindrical column interface, which creates superconducting quantum wells (SQWs) in the interface. The heat capacity results indicated that the new model is suitable for explaining the superconductivity of LK-99. The unique structure of LK-99 that allows the minute distorted structure to be maintained in the interfaces is the most important factor that LK-99 maintains and exhibits superconductivity at room temperatures and ambient pressure.

Initial claims

arXiv:2307.12008

$$Pb_{10-x}Cu_x(PO_4)_6O$$

We named the first room temperature and ambient pressure superconductor LK-99.

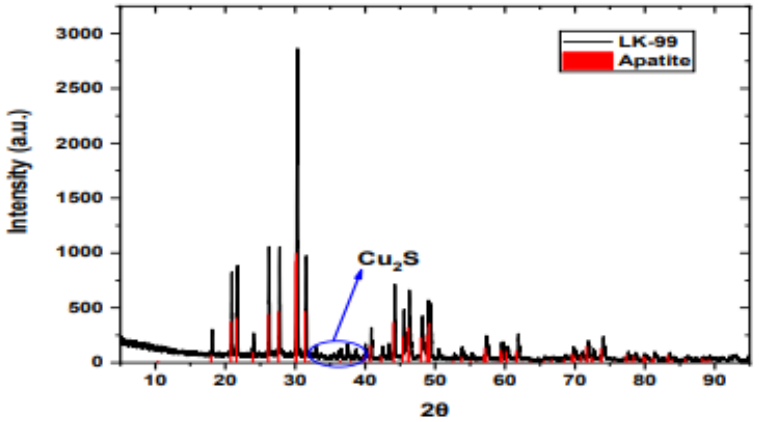
Sukbae Lee[1*], Ji-Hoon Kim[1], Young-Wan Kwon[2†]

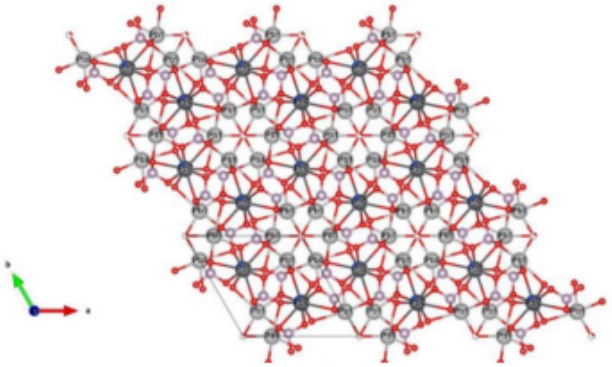
[1]Quantum Energy Research Centre, Inc., (Q-centre, Inc.), B1, 46-24, Songi-ro 23 gil, Songpa-gu, Seoul 05822, Korea

[2]KU-KIST Graduate School of Converging Science and Technology, Korea University, Seoul 02841, Korea

X-ray diffraction

arXiv:2307.12008



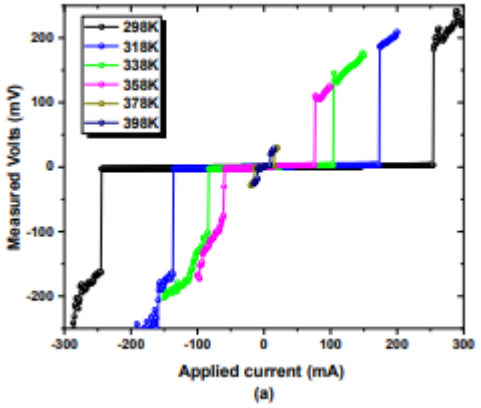


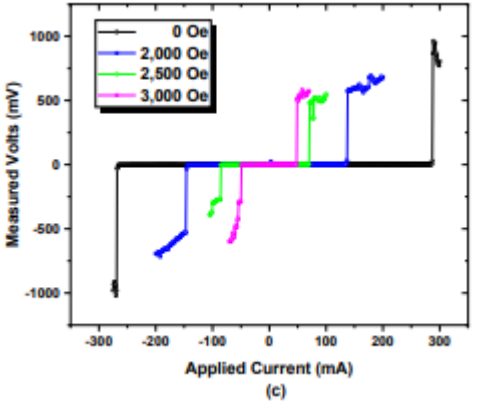
(a)

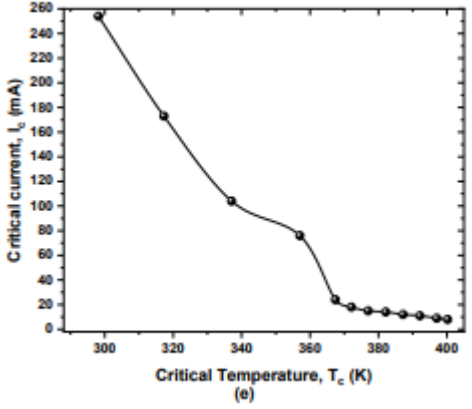
(b)

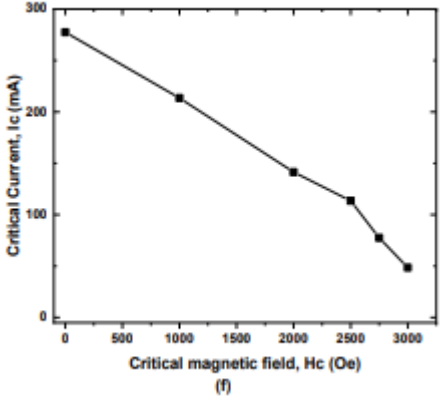
Initial claims

arXiv:2307.12008



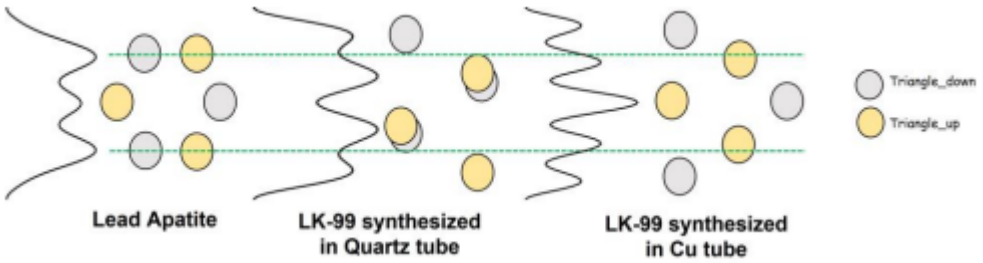


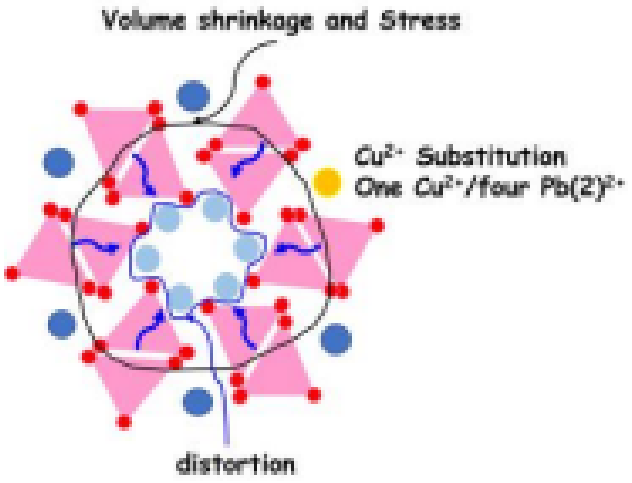




Initial claims

arXiv:2307.12008





More data

arXiv:2307.12037

[Submitted on 22 Jul 2023 (v1), last revised 11 Aug 2023 (this version, v3)]

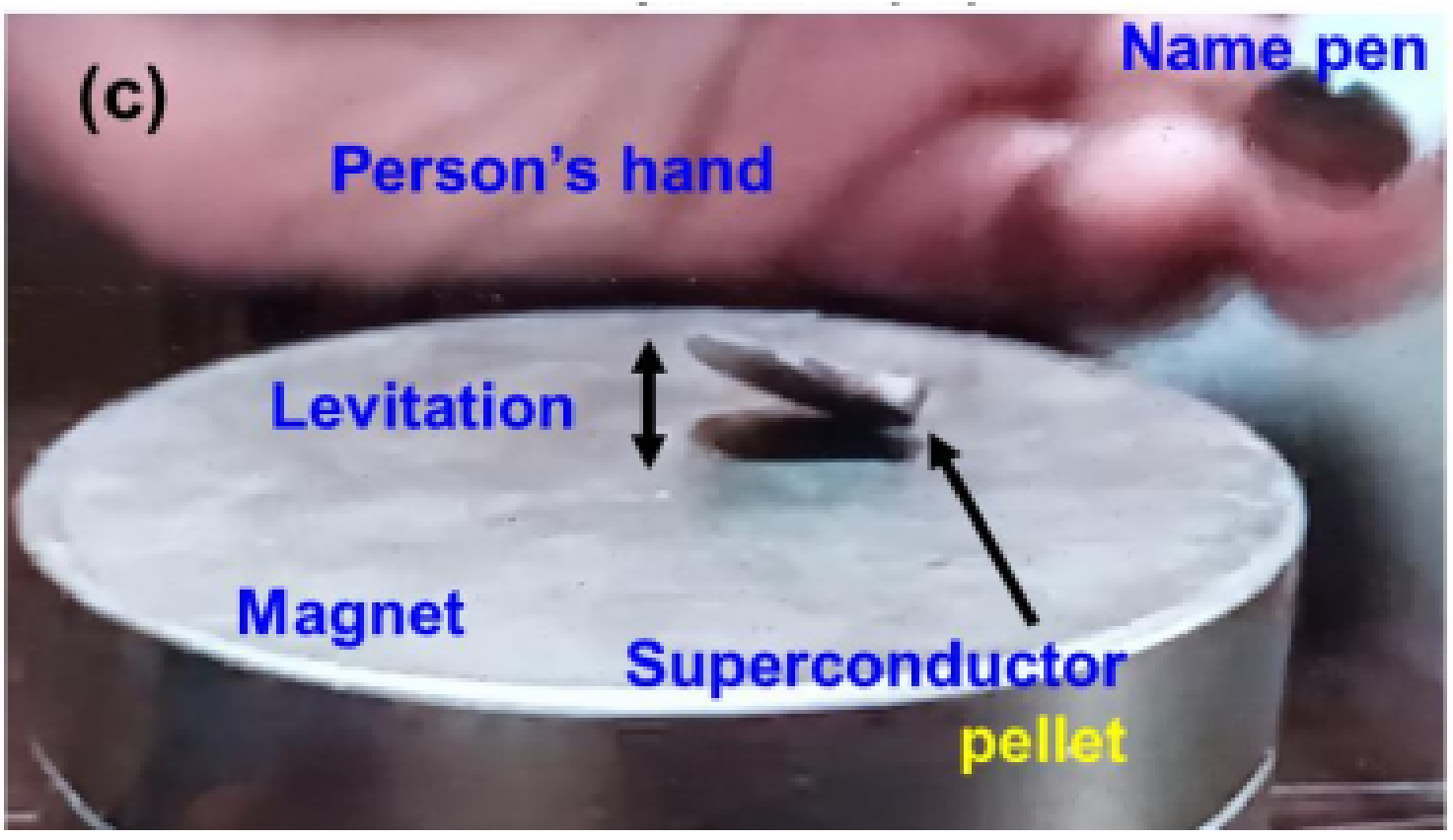
Superconductor $Pb_{10-x}Cu_x(PO_4)_6O$ showing levitation at room temperature and atmospheric pressure and mechanism

Sukbae Lee, Jihoon Kim, Hyun-Tak Kim, Sungyeon Im, SooMin An, Keun Ho Auh

A material called LK-99, a modified-lead apatite crystal structure with the composition $Pb_{10-x}Cu_x(PO_4)_6O$ $(0.9 < x < 1.1)$, has been synthesized using the solid-state method. The material exhibits the Ohmic metal characteristic of Pb(6s1) above its superconducting critical temperature, T_c, and the levitation phenomenon as Meissner effect of a superconductor at room temperature and atmospheric pressure below T_c. A LK-99 sample shows T_c above 126.85°C (400 K). We analyze that the possibility of room-temperature superconductivity in this material is attributed to two factors: the first being the volume contraction resulting from an insulator-metal transition achieved by substituting Pb with Cu, and the second being on-site repulsive Coulomb interaction enhanced by the structural deformation in the one-dimensional(D) chain (Cu^{2+}-$O_{1/2}$-Cu^{2+} along the c-axis) structure owing to superconducting condensation at T_c. The mechanism of the room-temperature T_c is discussed by 1-D BR-BCS theory.

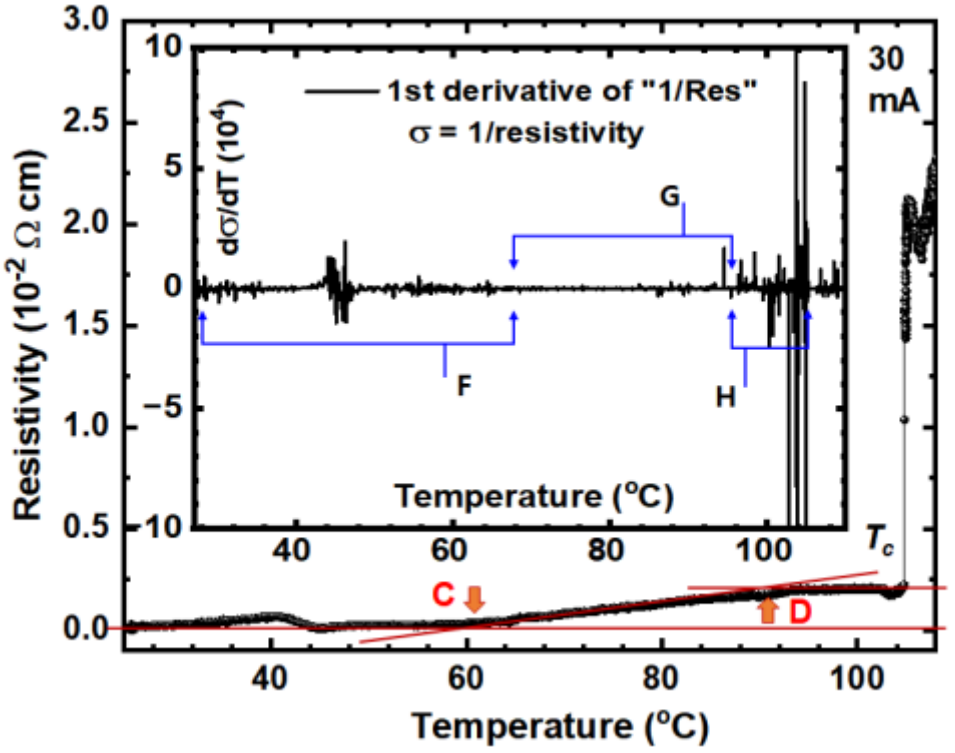
Levitation

arXiv:2307.12037



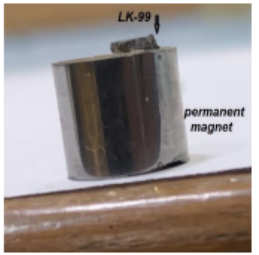
Resistivity

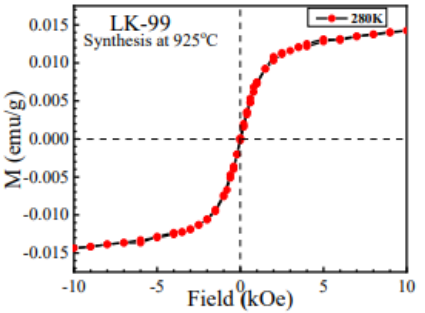
arXiv:2307.12037



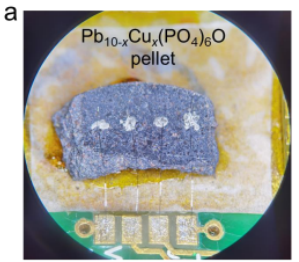
Scrutiny

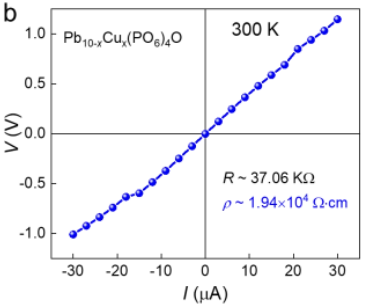
Kumar, K., Karn, N. K. & Awana, V. P. S.
Preprint at https://arxiv.org/abs/2307.16402

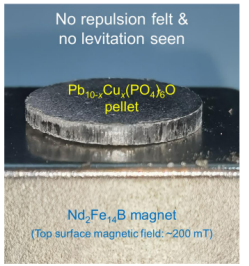




Liu, L. et al.
Preprint at https://arxiv.org/abs/2307.16802 (2023)



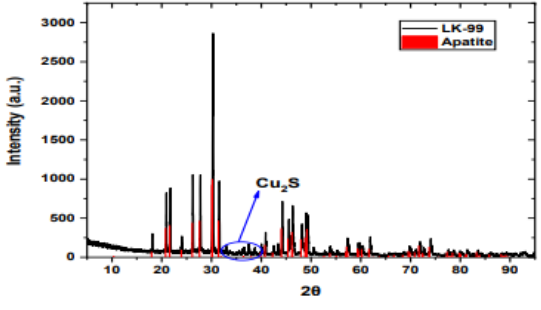




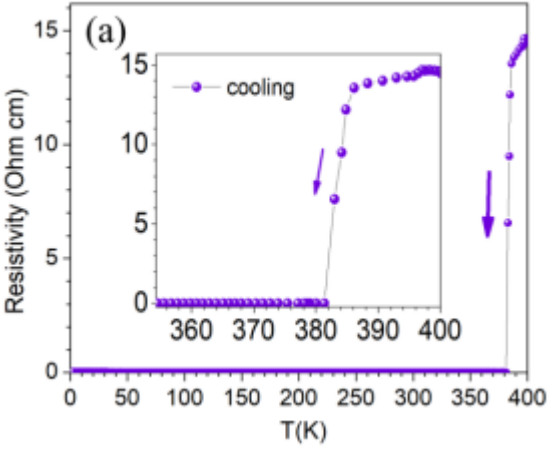
A bunch of DFT: metal, semiconductor, superconductor… - unknown structure

The answer

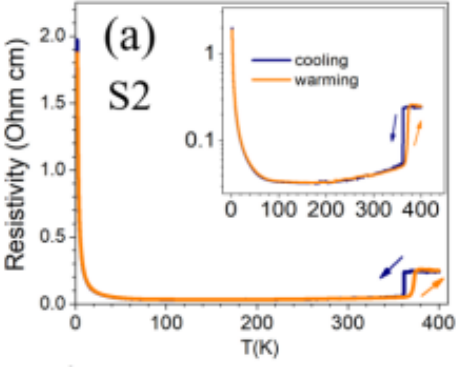
Zhu, S., Wu, W., Li, Z. & Luo, J.
Preprint at https://arxiv.org/abs/2308.04353

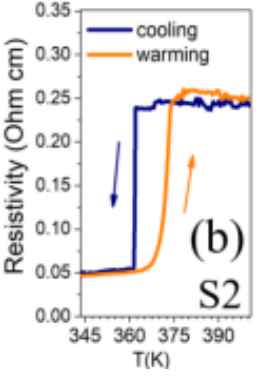


Cu2S



LK-99+Cu2S





The answer

Arxiv: 2309.17445

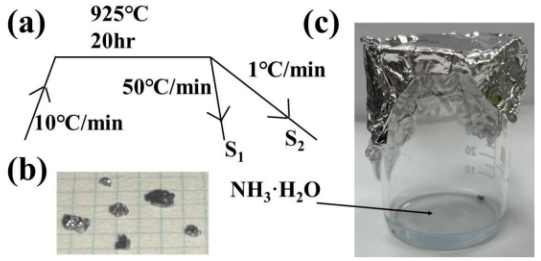
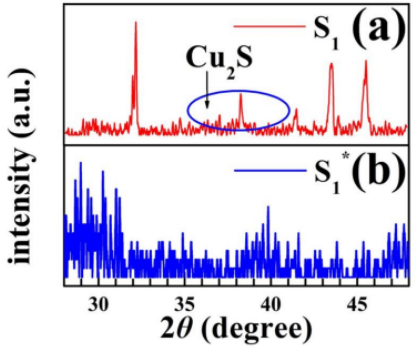


Fig. 1 Synthesis process of LK-99. a Schematic process of final procedure with different cooling rates denoted as S1 and S2. **b** The images of S1. **c** The image of the S1 immersed in ammonia solution, showing a light blue color of Cu^{2+}.



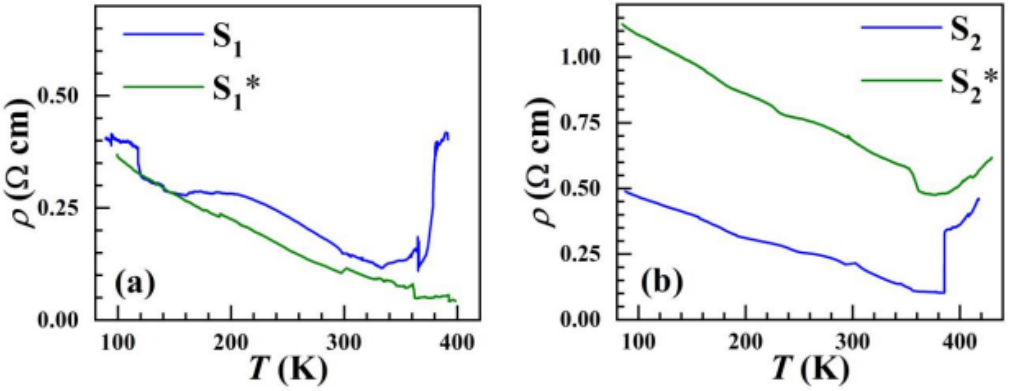


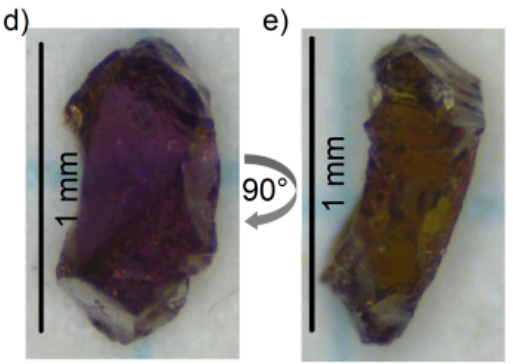
Fig. 4 Basic resistive properties of LK-99. a Resistivity of S1 shown in blue, and resistivity of S1* depicted in green. **b** Resistivity of S2 shown in blue, and resistivity of S2* depicted in green. The apparent transition near 380 K is conspicuously absent in S1* and S2*.

More evidence

Jiang, Y. et al. Preprint at https://arxiv.org/abs/2308.05143

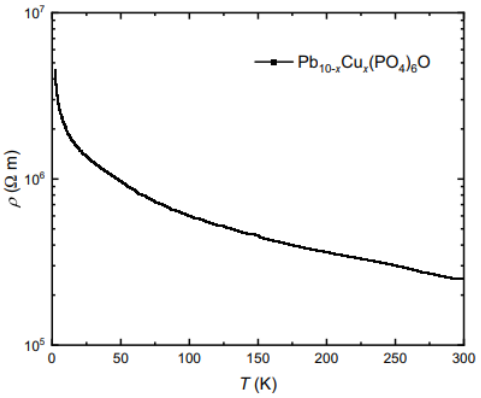
XRD+DFT = insulator

Puphal, P. et al. Preprint at https://arxiv.org/abs/2308.06256

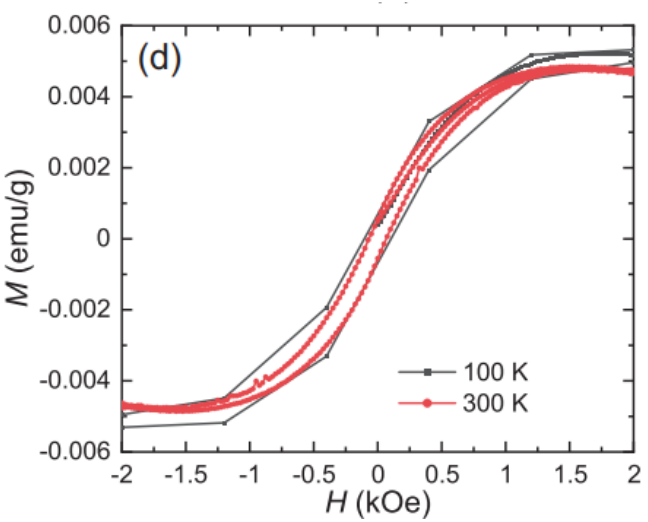


Single-crystal synthesis = non-magnetic insulator

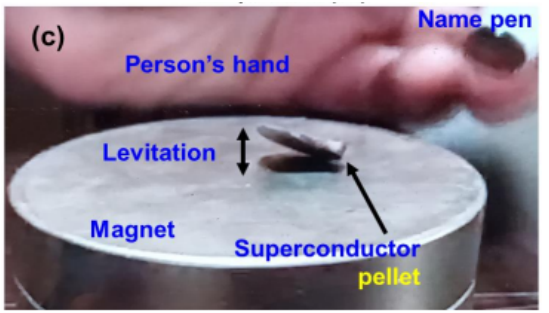
Levitation

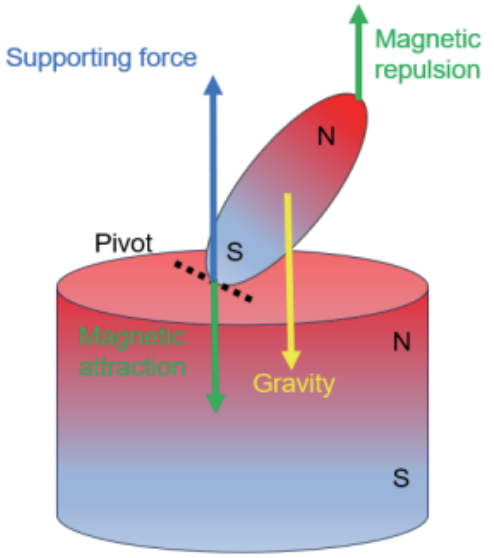


Insulator



Ferromagnet





Guo, K., Li, Y. & Jia, S. Ferromagnetic half levitation of LK-99-like synthetic samples. Sci. China Phys. Mech. Astron. 66, 107411 (2023)

Science etiquette in Korea

Youtube: