

The First Room-Temperature Ambient-Pressure Superconductor

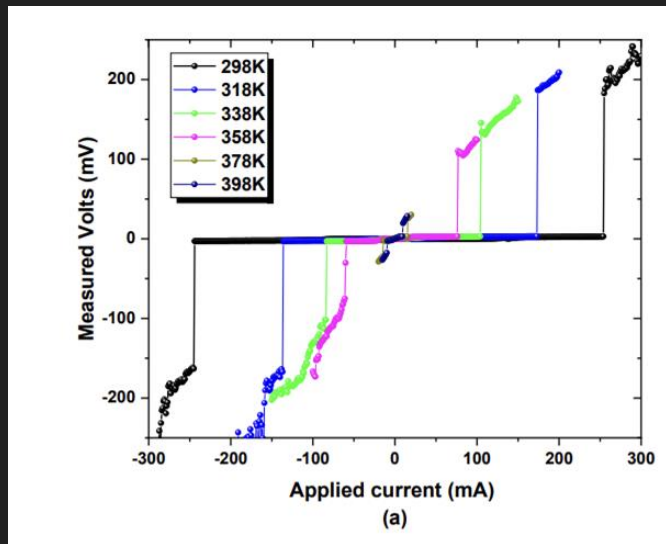
Sukbae Lee, Ji-Hoon Kim, Young-Wan Kwon (Arxiv 22 Jul
2023)

Team 8

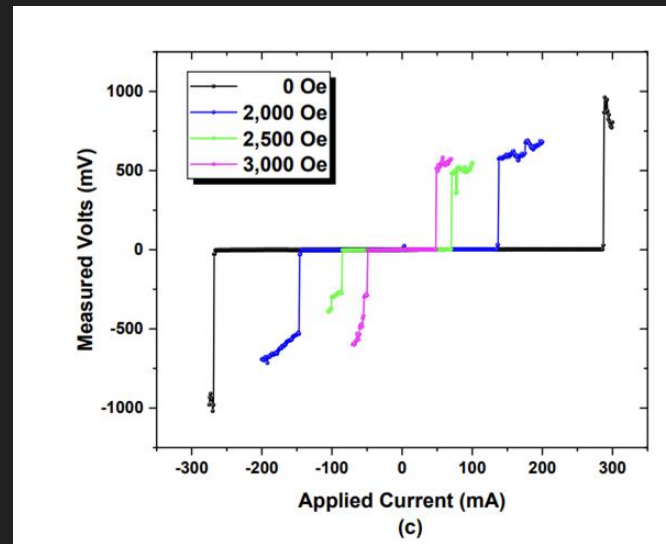
Derek Pan, Avani Paghadal, Logan Mueller, Sydnee O'Donnell, Calvin Nettelhorst_(rip)

PHYS 596 Fall 2023

Apparent Superconductivity Above Room Temperature in LK-99



Resistivity drop above room temperature

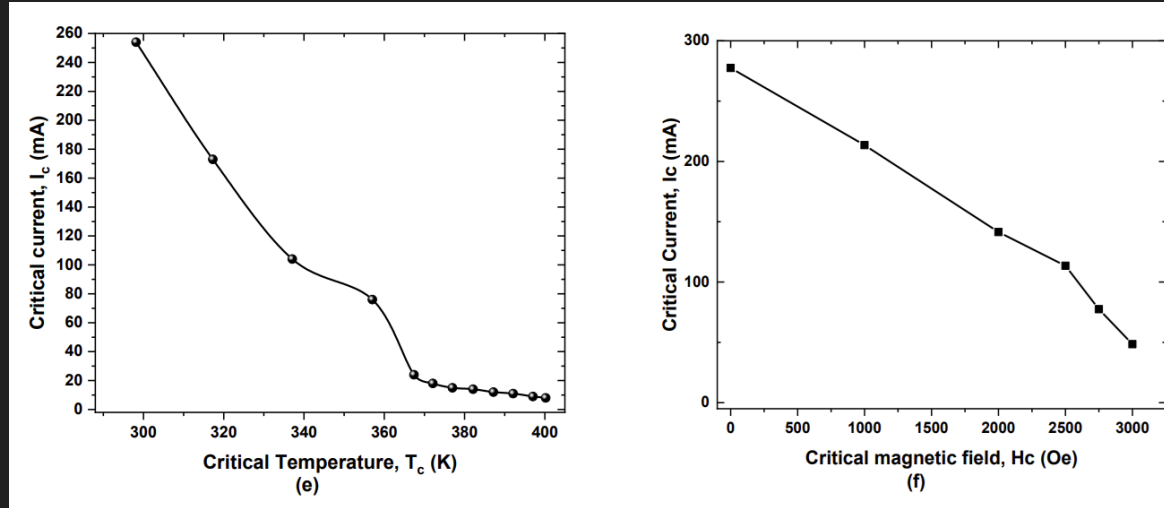


Resistivity drop persists in high magnetic fields

Lee, Sukbae, Ji-Hoon Kim, and Young-Wan Kwon. 2023. The First Room-Temperature Ambient-Pressure Superconductor. arXiv: 2307.12008 [cond-mat.supr-con].

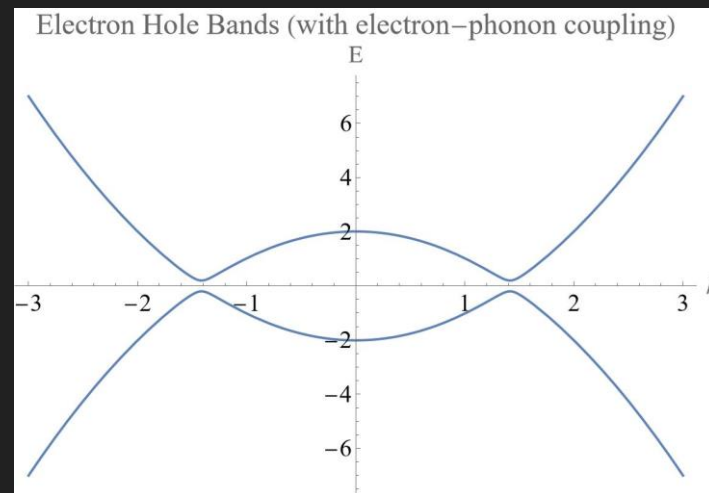
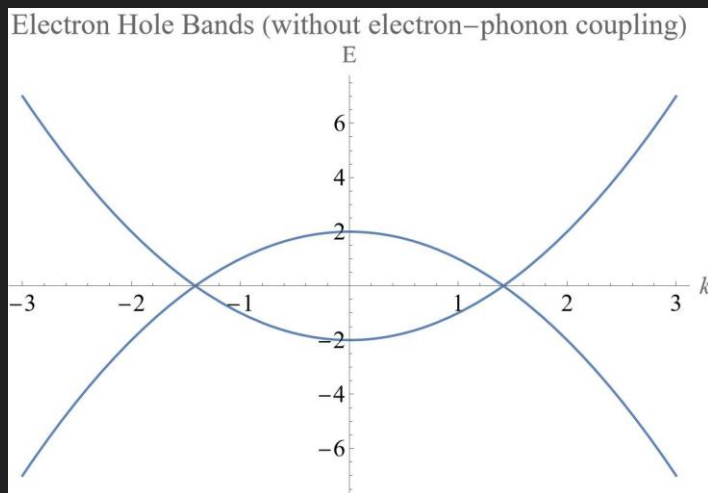
Robustness of Superconducting State at High Temperature

- Critical current is non-zero all the way up to 400 K and 3000 Oer



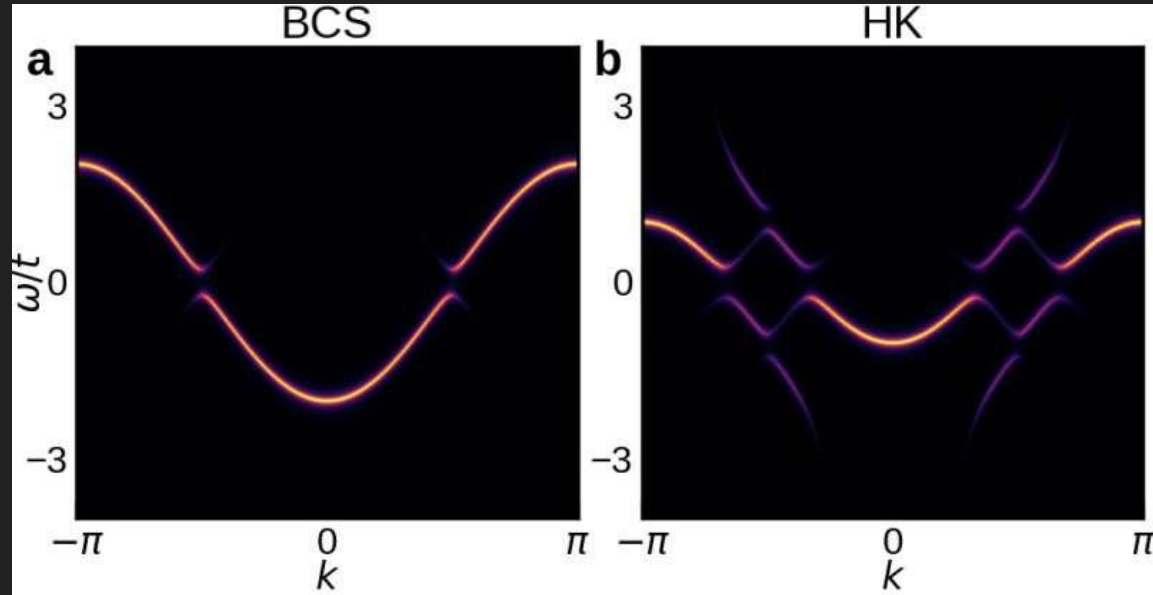
Mechanism Behind Superconductivity in Metals

- BCS theory tells us that electron-phonon coupling leads to electron and hole pair formation below a certain temperature



Superconductors beyond BCS theory

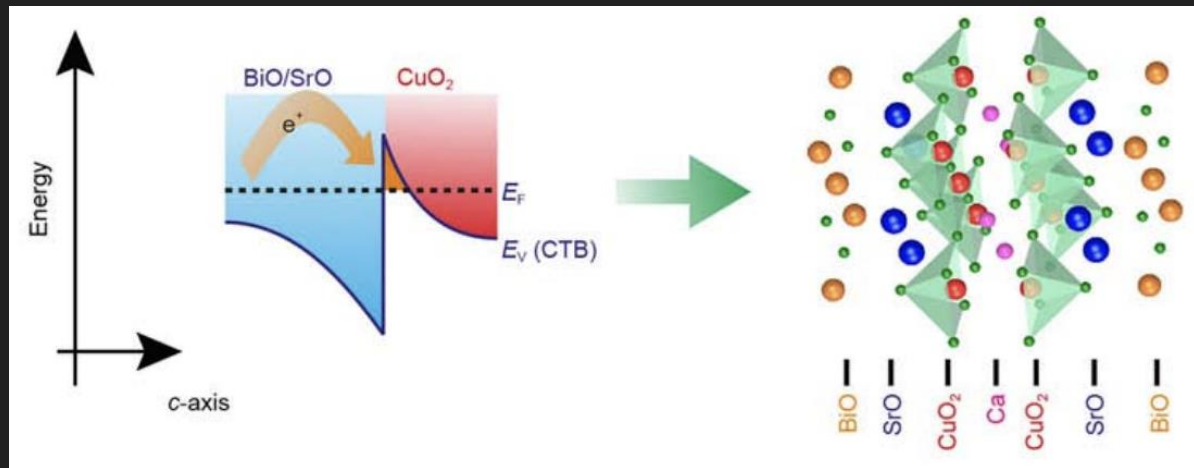
- Some materials show superconducting characteristics above reasonable temperatures for BCS theory
- Electron correlations are an example of a possible explanation



Phillips, P.W, Nat. Phys. 16, 1175–1180 (2020).

Superconducting From Quantum Wells in Cuprates

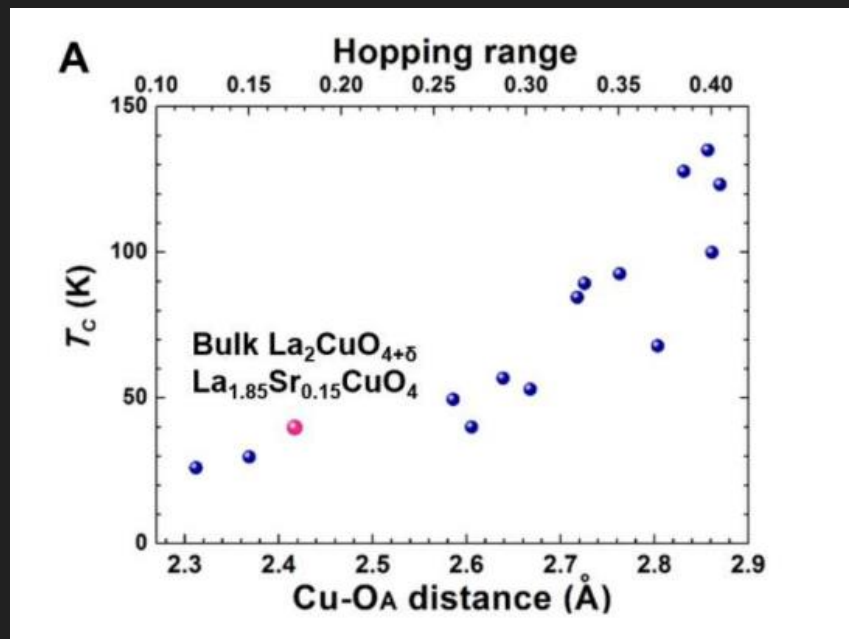
- This phenomenon is famously seen in cuprates
- Doping is responsible for the superconducting transition from insulator
- In $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+d}$, quantum wells at the $\text{SrO}(\text{BiO})/\text{CuO}_2$ interface proposed to provide doping



Zhong, et al. 2016. Science Bulletin 61 (16):

Evidence for Strain-induced Superconducting properties

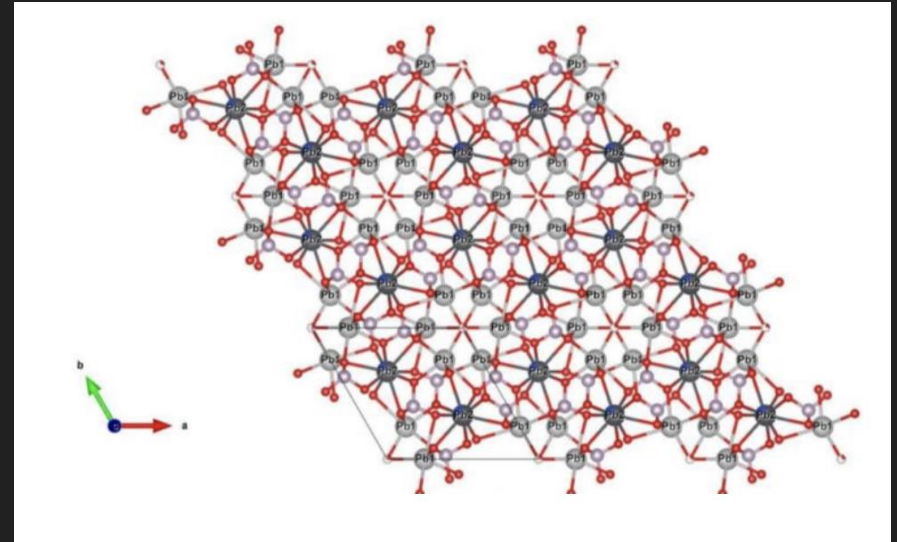
- Evidence that physical stress and structural distortion in cuprates is responsible for higher T_c



Choi, et al. 2019. Science Advances 5 (4)

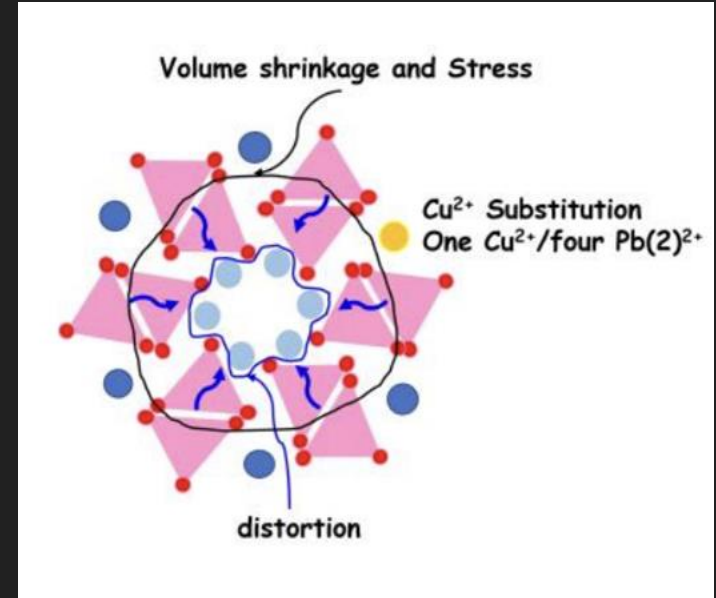
LK-99: Crystal Structure

- LK-99 has a modified Lead-apatite structure which is polycrystalline in nature



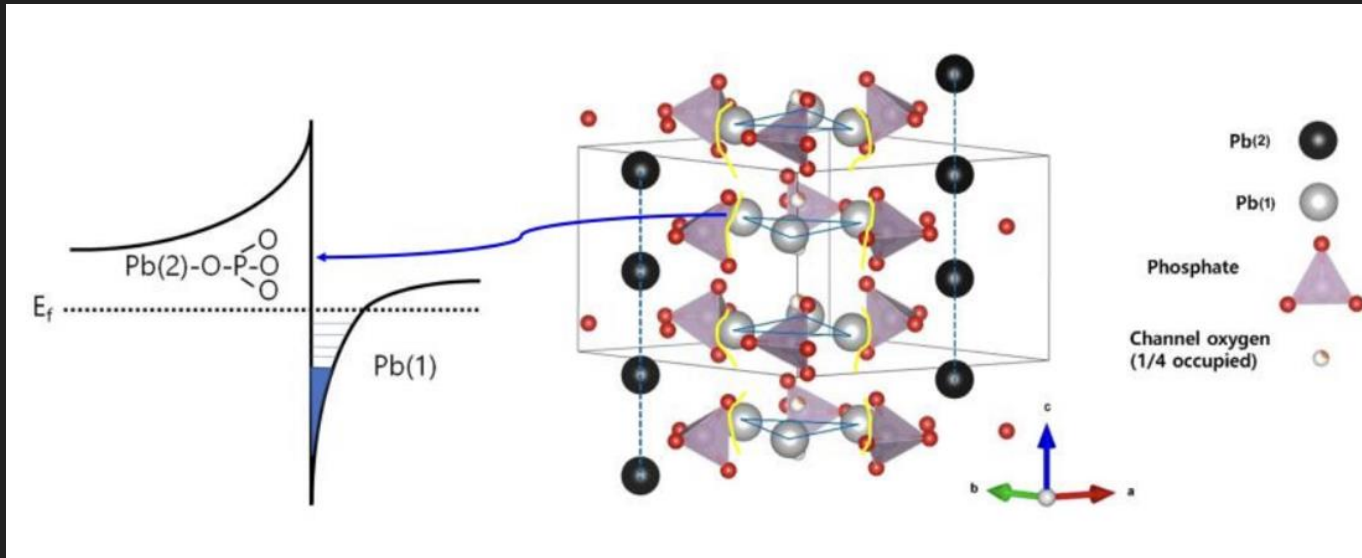
LK-99: Effect of Impurities on Crystal structure

- LK-99 is a modified Lead-apatite structure which is polycrystalline in nature
- Cu^{2+} impurities cause structural strain in to form of a volume reduction of 0.48%



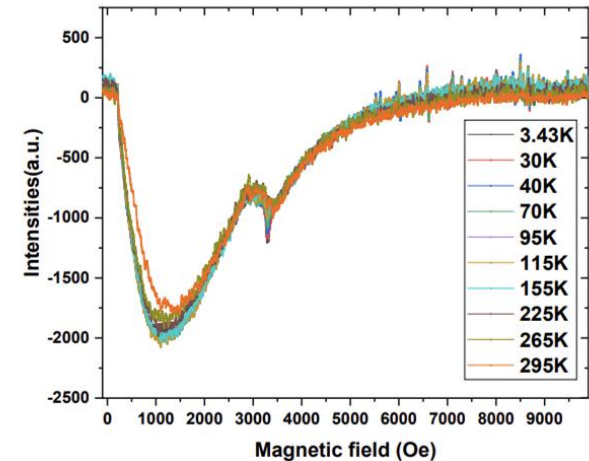
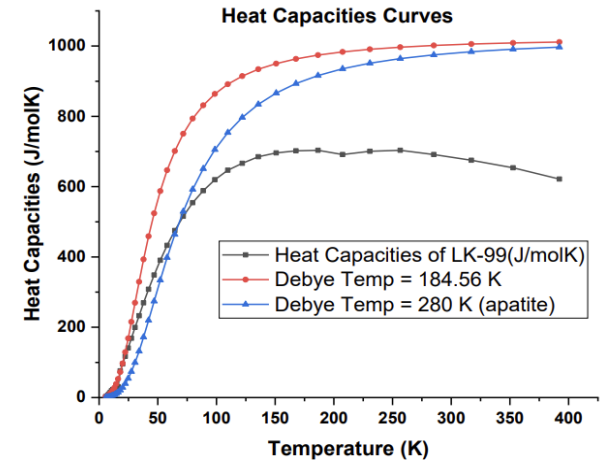
LK-99: Superconducting Quantum Wells

- Strain causes the formation of quantum wells between Pb(1) and the oxygen atoms in the phosphate

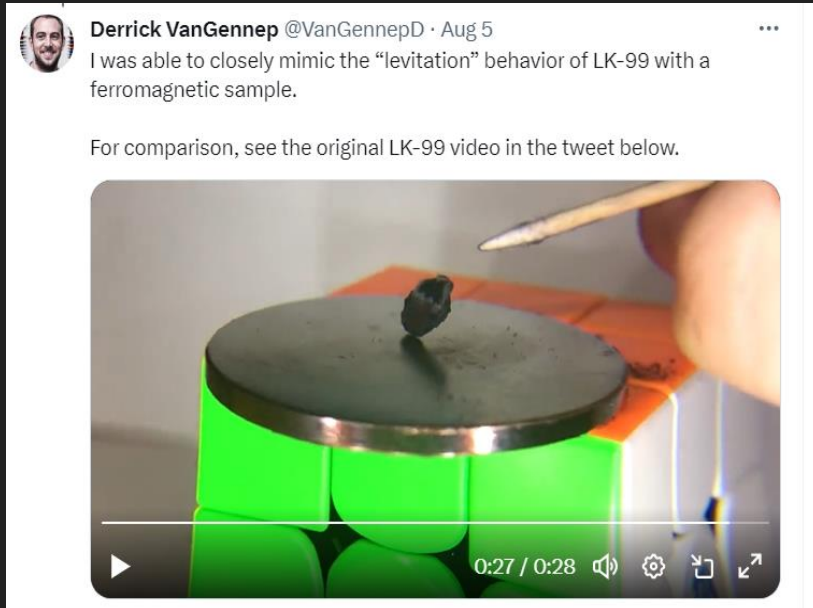


LK-99 Evidence for Structural Change

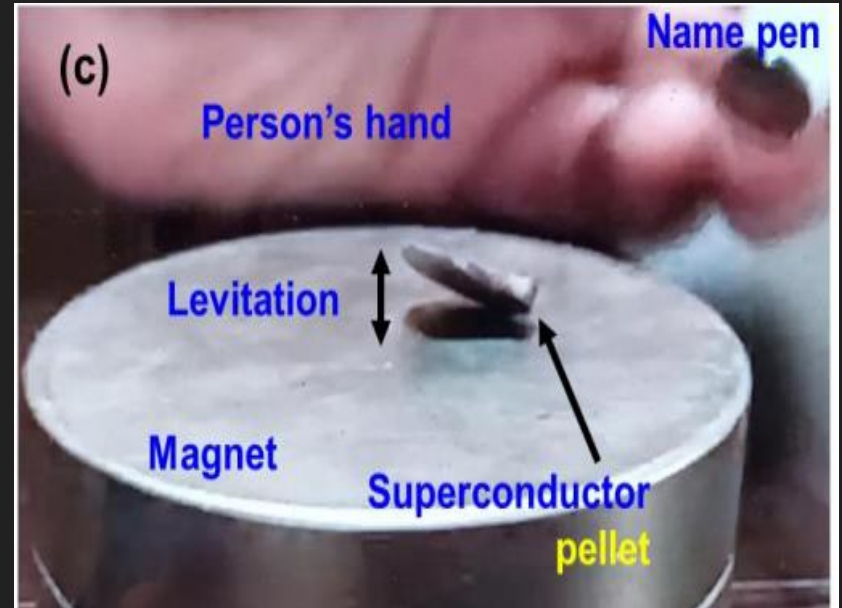
- Electron paramagnetic resonance measurement evidence for existence of quantum wells at the interface (1000 Oe)
- Existence of Cu²⁺ impurities causing distortion (3000 Oe)
- Heat capacity shows that structure is distorted from standard lead apatite



Ferromagnetic Behavior in LK-99



Experiment: Construction of a pellet with compressed graphite shavings and iron filings. Video demonstration showing behavior similar to LK-99.



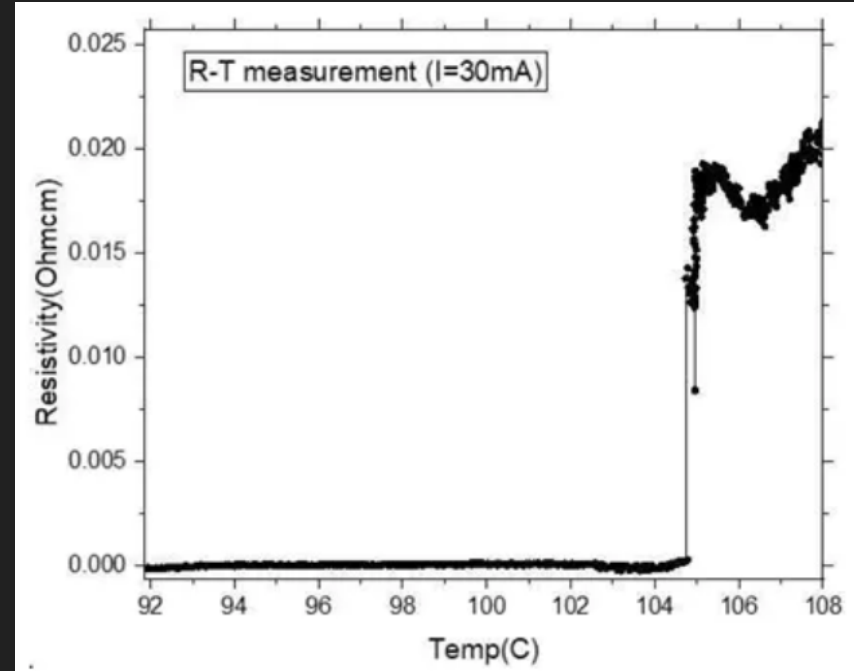
Levitation observed by the South Korean Group

Resistivity Measurements in LK-99

- Observed a tenfold drop at a specific temperature @ 104.8 °C/ 337 K.

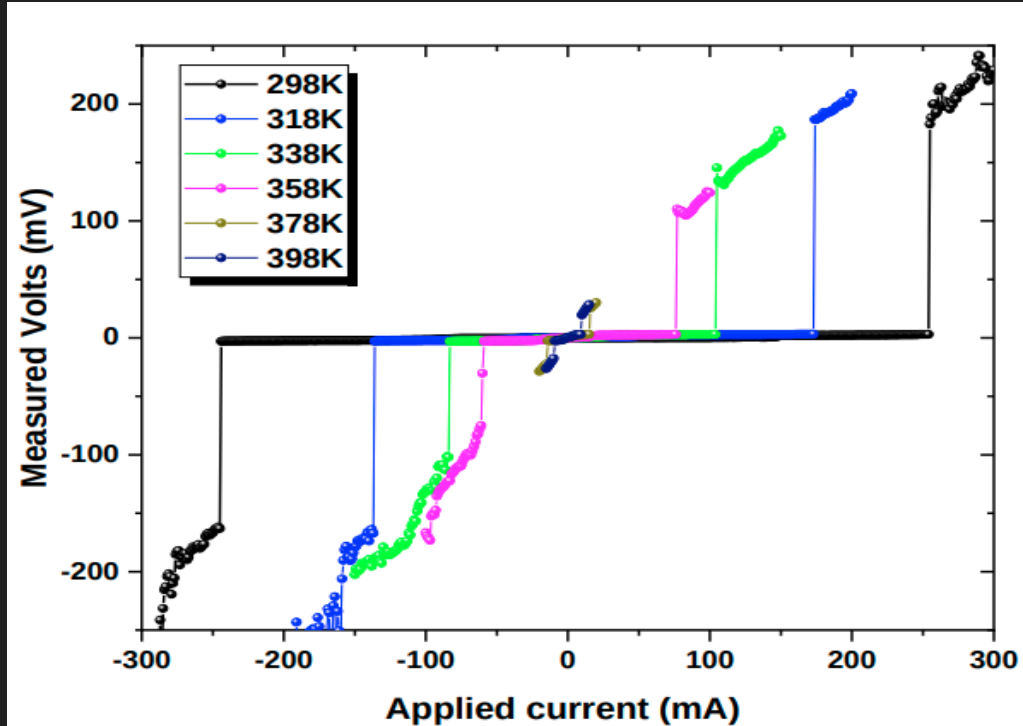
Chinese Academy of Sciences [CAS]
Team's Insights :

- Effects of Cu_2S impurities in LK-99, it contains Cu_2S impurities, which undergoes phase transition @ ~ 104°C - CAS Team [Chinese Academy of Sciences].



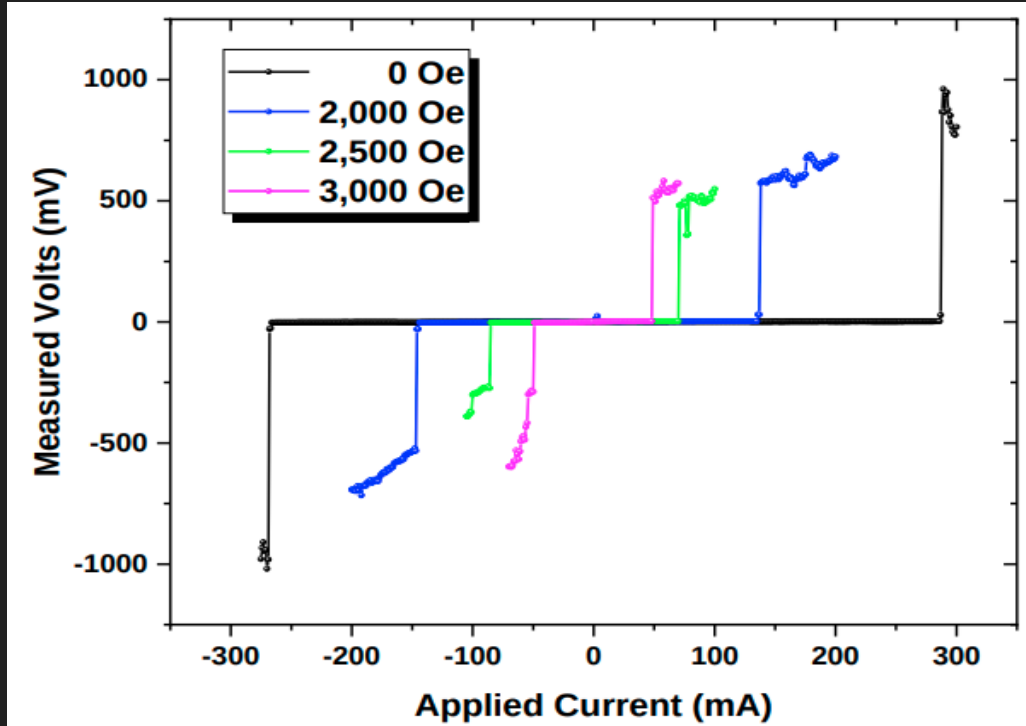
The graph above showcases what's generally to be expected of a superconductor: a falling resistivity cliff around a phase-transition critical temperature (T_c).

LK-99 Exhibits Evidence for Superconductivity



- Bulk: 10^{-6} to 10^{-9} $\Omega \cdot \text{cm}$
- Thin Film: 10^{-10} to 10^{-11} $\Omega \cdot \text{cm}$
- SC: 10^{-11} $\Omega \cdot \text{cm}$

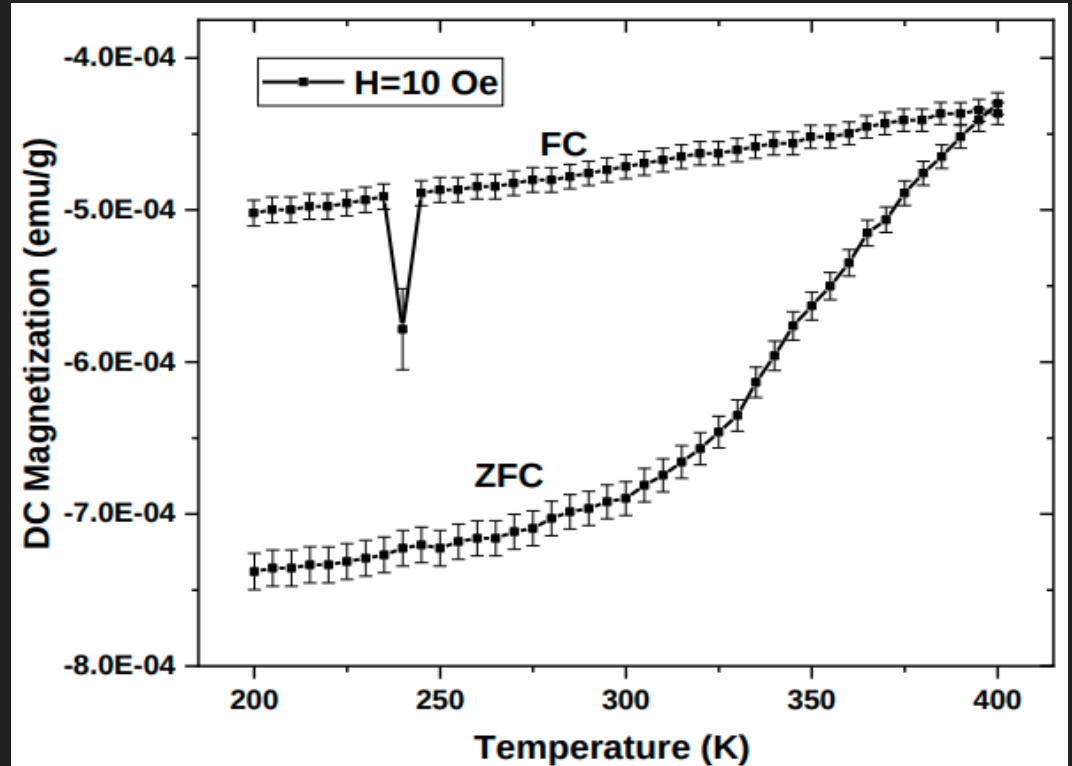
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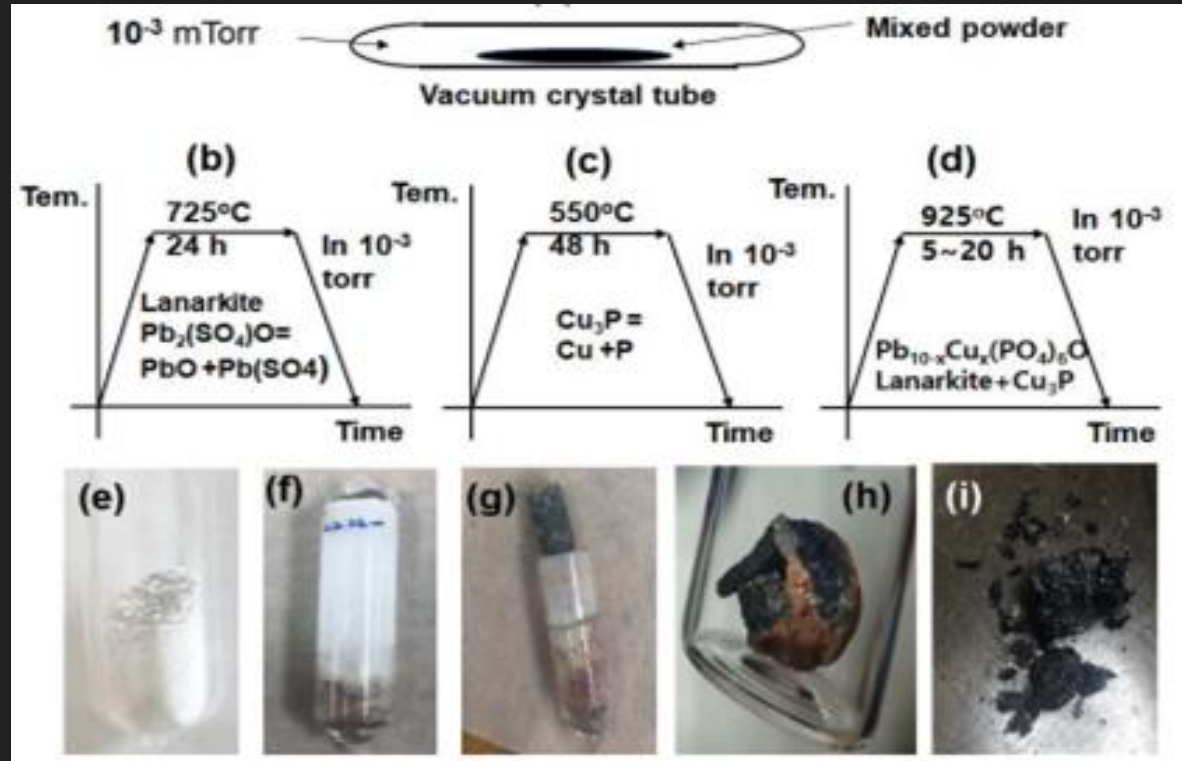
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LK-99 Exhibits Evidence for Superconductivity

- FC ZFC mode splitting at 395°K
- Difficulty reproducing



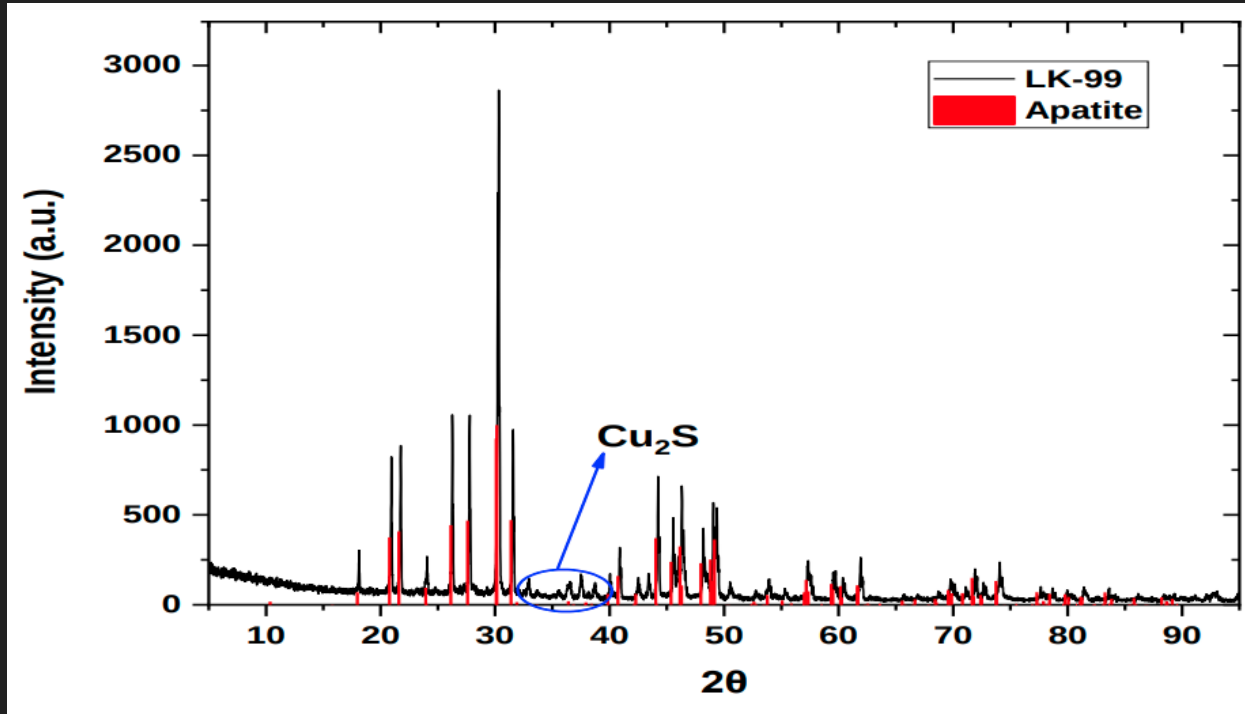
Synthesis of LK-99



Very simple processes

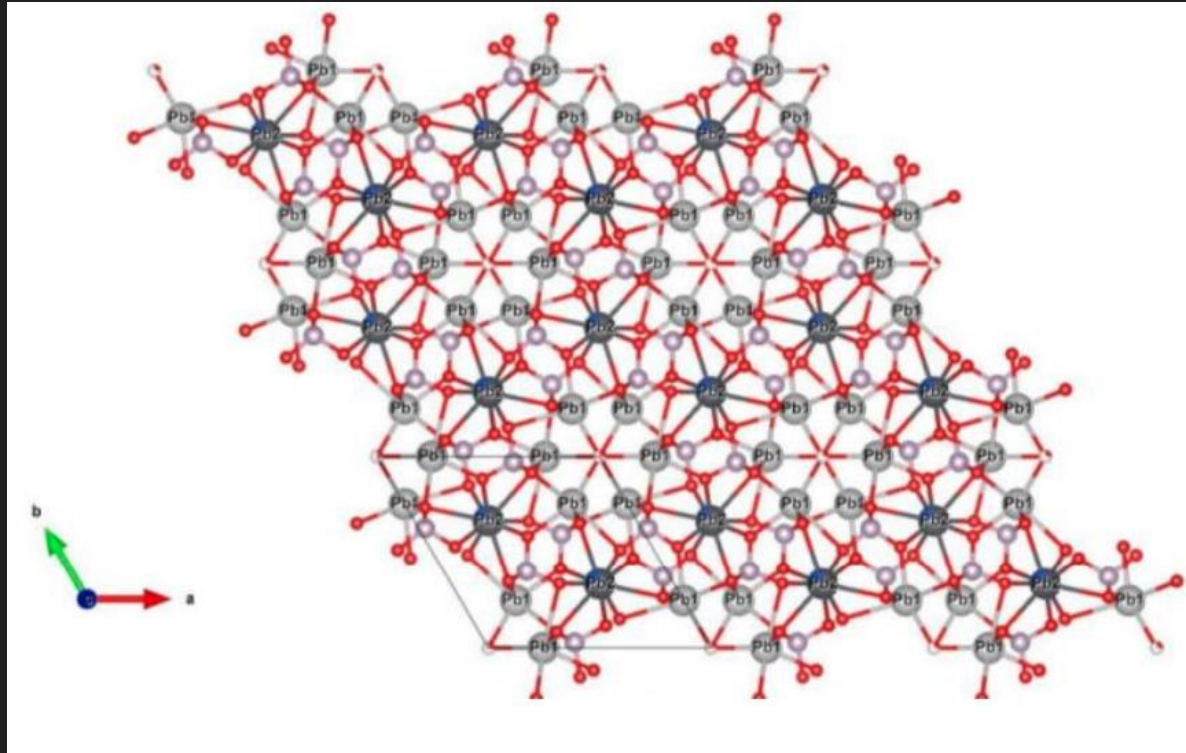
But samples are impure

XRD of LK-99 Compared to Lead Apatite



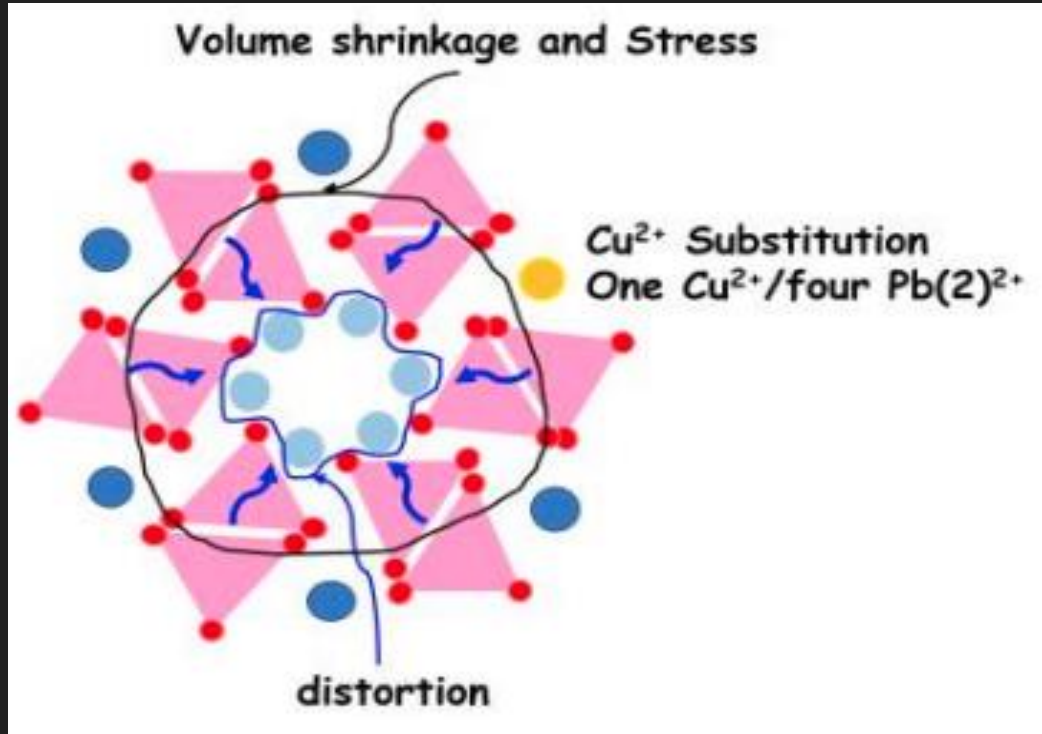
- Cu₂S replacement
- Data shift compared to Apatite
- Interpreted as volume decrease mainly in a-b axis

Molecular Structure of LK-99



- Cu₂S replacement
- Data shift compared to Apetite
- Interpreted as volume decrease mainly in a-b axis

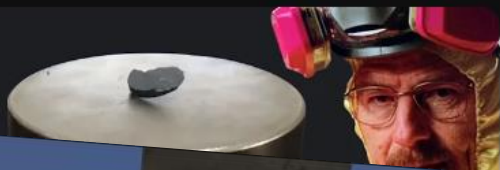
Molecular Structure of LK-99



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- Interpreted as volume decrease mainly in a-b axis

Claim as to Source of Superconductivity in LK-99

- Volume change and structural distortion resulting in stress
- Stress causes SQW leading to superconductivity
- Much more research and data is needed to verify these claims



"World-changing" LK-99 Superconductor explained quickly

1M views • 4 months ago



Science

Commentary Home Opinion Analysis Blogs

A ROOM-TEMPERATURE SUPERCONDUCTOR? NEW DEVELOPMENTS

A Room-Temperature Superconductor? New

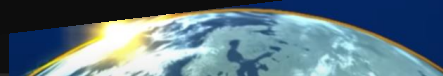
LK-99 ¿el primer superconductor a temperatura ambiente? #ciencia #química #experimento #física

4.6M views



LK-99 Superconductor Breakthrough - Why it MATTERS!

1.8M views • 4 months ago



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Conductivity Superconductivity

discovered material has that could be precious for ductivity

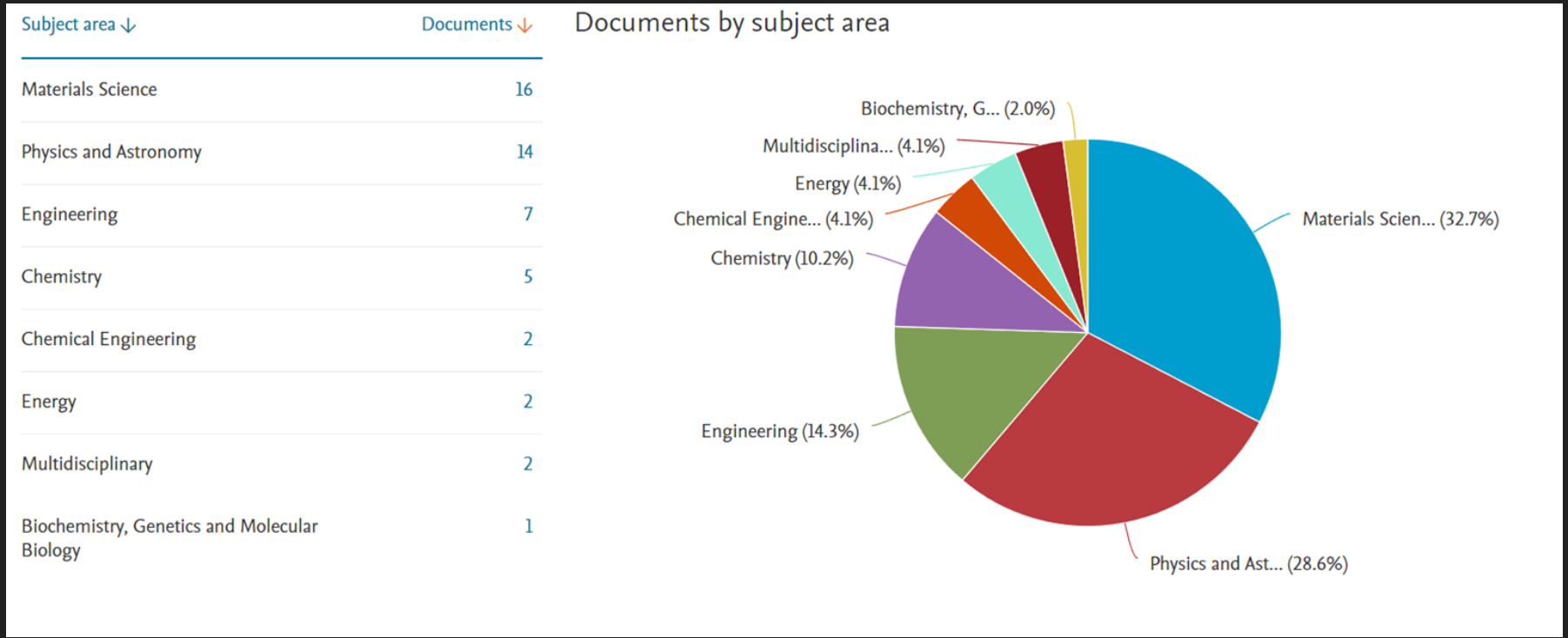


SCIENCE

LISTEN & FOLLOW

Scientists are skeptical of mysterious supposedly superconductive material

SCOPUS search - keyword "Ik-99"



Summary of Paper

Comparison

Critical Analysis

Citations & Future Work

The future of LK-99

- Most sources believe Lk-99 in its pure form to be an insulator
- Still some ongoing tests
- In fact...
 - <https://arxiv.org/pdf/2003.14321#:~:text=Abstract%20%7C%20A%20long-standing%20problem,to%20an%20appropriate%20Tc%20value.>



Recreation Attempts - “Future” Work

[Claims of Room Temperature and Ambient Pressure Superconductor | Page 13 | SpaceBattles](#)

Summary of Paper

Comparison

Critical Analysis

Citations & Future Work

Questions?

Thank you!

LK99 is a
superconductor
because it floats



DFT and
simulations confirm it



No one else
has repeated the
protocol correctly



But what if there
is a secret recipe



imgflip.com



Team 8

Derek Pan, Avani Paghadal, Logan Mueller, Sydnee O'Donnell, Calvin Nettelhorst (who lives on in our memories)

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