l'électricité

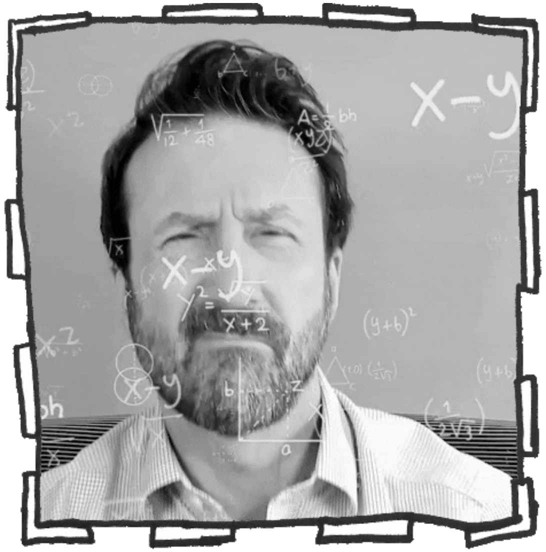
Culture scientifique en L3
Institut Villebon-Charpak, Julien Bobroff

l'électricité

expliquez à un enfant
de 10 ans ce que c'est

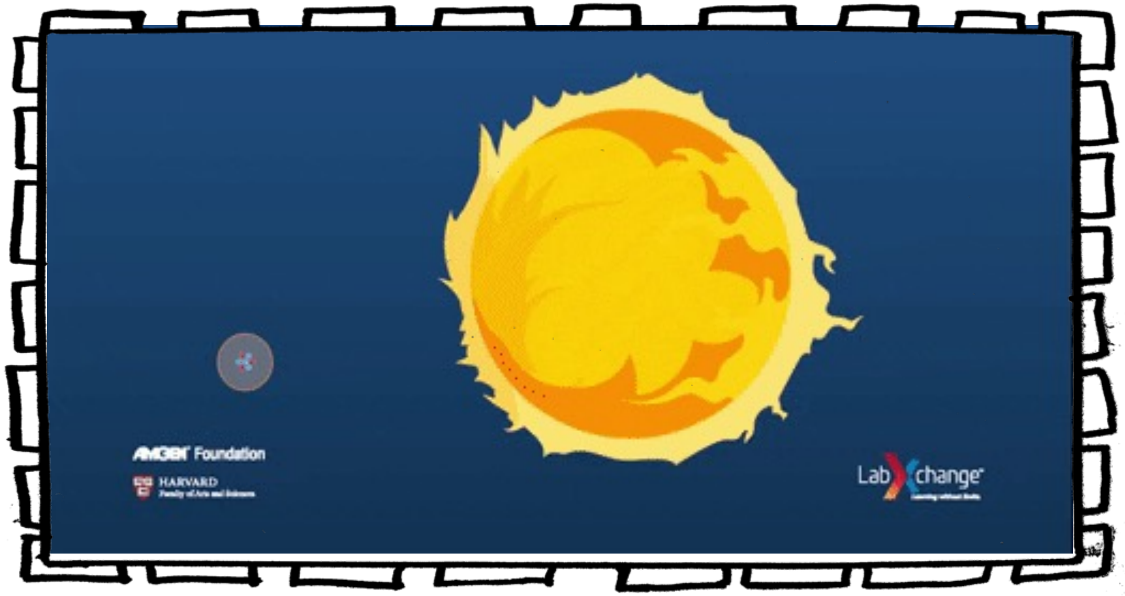
l'électricité

quelles équations ?



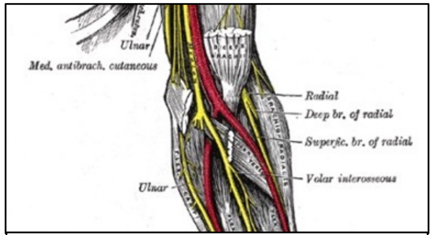
l'électricité

les ordres de grandeur



intensité électrique (A) : du plus petit au plus grand

grille-pain



nerfs

TGV

ordi portable

tension électrique (V) : du plus petit au plus grand

chaise électrique

cellule nerveuse

batterie voiture

éclair

puissance (W) : du plus petit au plus grand

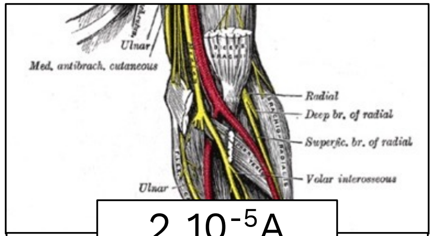
centrale nucélaire

éolienne

barrage d’Assouan

panneau solaire
(1m^2)

intensité électrique (A) : du plus petit au plus grand



$2\ 10^{-5}$A

nerfs

5 A

ordi portable

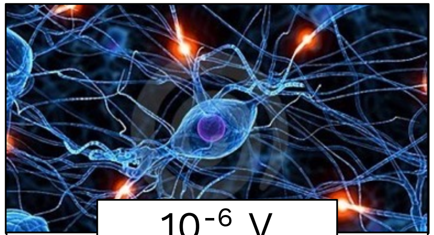
10 A

grille-pain

500 A

train

tension électrique (V) : du plus petit au plus grand



10^{-6} V

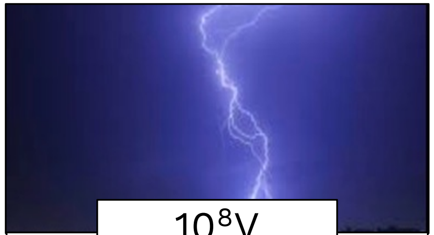
cellule nerveuse

12 V

batterie voiture

2000 V

chaise électrique



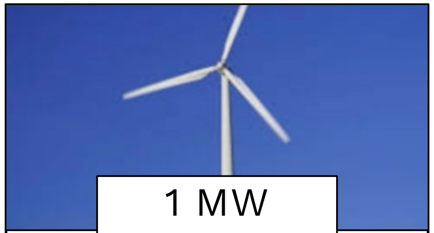
10^8V

éclair

puissance (W) : du plus petit au plus grand

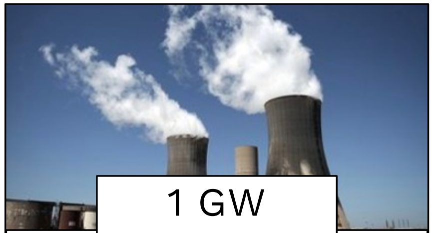
100 W

panneau solaire (1m^2)



1 MW

éolienne



1 GW

centrale nucélaire

2 GW

barrage d'Assouan

l'électricité

recherches récentes

recherches récentes

1. guider la foudre
2. la supraconductivité à haute température
3. la supra sous pression
4. la supra dans le graphène
5. un cas de buzz médiatique

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nature photonics

Article

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Laser-guided lightning

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Lightning discharges between charged clouds and the Earth's surface are responsible for considerable damages and casualties. It is therefore important to develop better protection methods in addition to the traditional Franklin rod. Here we present the first demonstration that laser-induced filaments—formed in the sky by short and intense laser pulses—can guide lightning discharges over considerable distances. We believe that this experimental breakthrough will lead to progress in lightning protection and lightning physics. An experimental campaign was conducted on the Säntis mountain in north-eastern Switzerland during the summer of 2021 with a high-repetition-rate terawatt laser. The guiding of an upward negative lightning leader over a distance of 50 m was recorded by two separate high-speed cameras. The guiding of negative lightning leaders by laser filaments was corroborated in three other instances by very-high-frequency interferometric measurements, and the number of X-ray bursts detected during guided lightning events greatly increased. Although this research field has been very active for more than 20 years, this is the first field-result that experimentally demonstrates lightning guided by lasers. This work paves the way for new atmospheric applications of ultrashort lasers and represents an important step forward in the development of a laser based lightning protection for airports, launchpads or large infrastructures.

Lightning has fascinated and terrified humankind since time immemorial. Based on satellite data, the total lightning flash rate worldwide—including cloud-to-ground and cloud lightning—is estimated to be between 40 and 120 flashes per second[1], causing considerable damage and casualties. The documented number of lightning fatalities is well above 4,000 (ref. 2) and lightning damages amount to billions of dollars every year[3]. The most widely used external protection against direct lightning strikes is still the lightning rod, also known as Franklin rod or lightning conductor. The lightning rod, whose invention in the 18th century is attributed to Benjamin Franklin, consists of a pointed conducting mast connected to the ground. It protects buildings and their immediate surroundings by providing a preferential strike point for the lightning and guiding its electric current safely to the ground.

A method to initiate lightning discharges with a small rocket trailing a long, grounded conducting wire was demonstrated by Newman et al. in 1965 (ref. 4). In contrast to the classical lightning rod, which

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Houard et al., Nature Photonics, 2022

Palaiseau, Geneve

2022

LASER POUR GUIDER LA FOUDRE

Fig. 1 | Image of the 124-m-high telecommunication tower of Säntis (Switzerland). Also shown is the path of the laser recorded with its second harmonic at 515 nm.

principe :
quand l'éclair arrive sur la tour, on envoie le laser

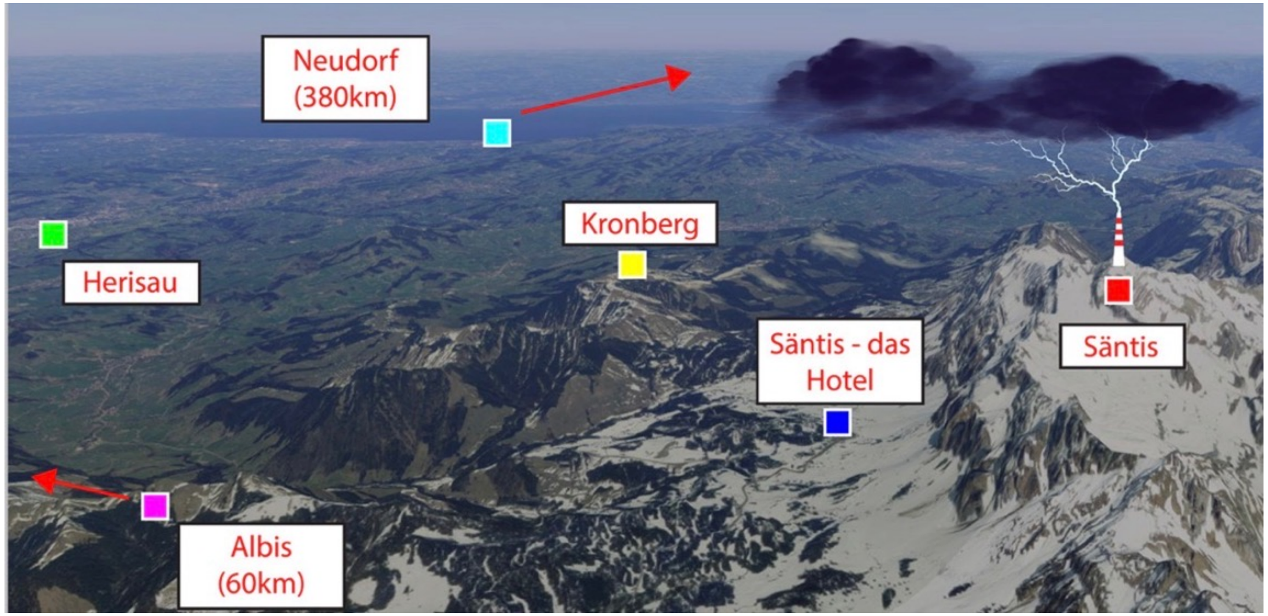
→ ionise l'air qui devient un plasma

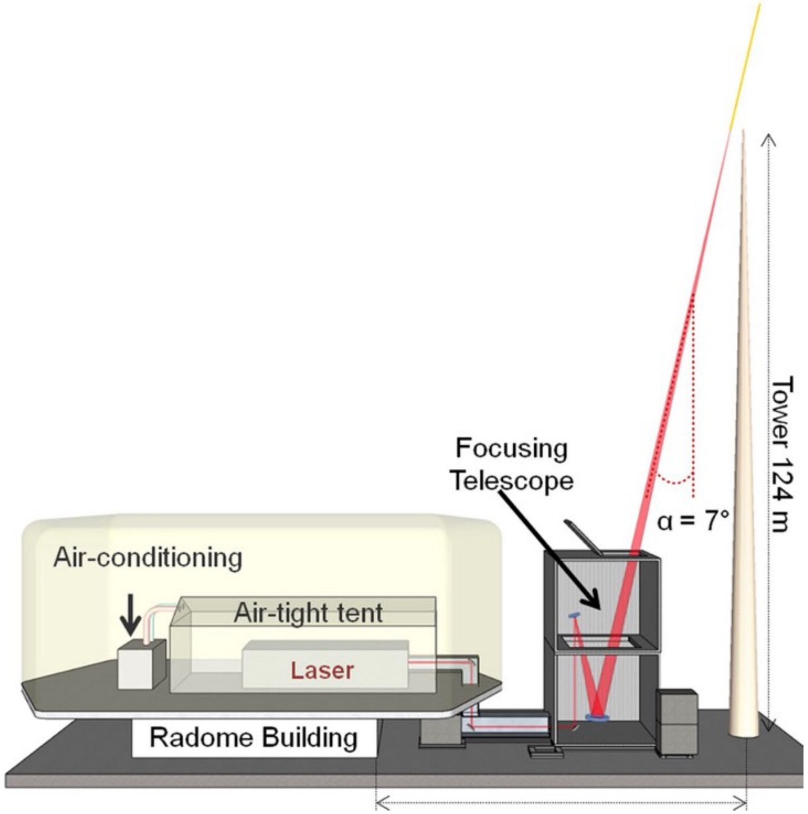
→les molécules d'air chauffent et partent radialement

→il reste des sortes de canaux de densité réduite d'une durée de vie d'une msec, de très bonne conductivité : idéal pour guider pour la foudre.

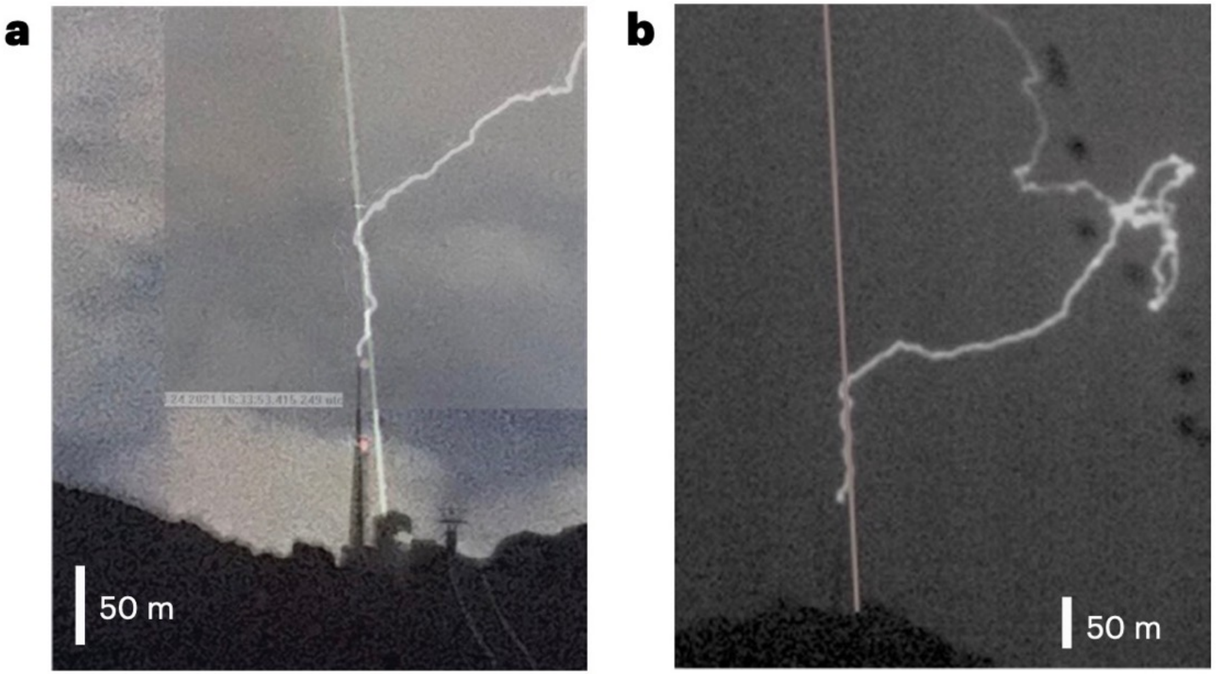
LASER POUR GUIDER LA FOUDRE

2022 : un nouveau laser envoie à 1000 fois par sec des impulsions puissantes en haut d’une montagne en Suisse où on sait où tombe l’éclair





LASER POUR GUIDER LA FOUDRE



Ils arrivent à guider la foudre pour la 1ère fois en 2022

interêt par rapport à un paratonnerre :
bien plus que slt qq mètres de portée (qq centaines de mètre)
→ on peut protéger une surface plus grande – exple : aéroport

recherches récentes

1. guider la foudre
2. **la supraconductivité à haute température**
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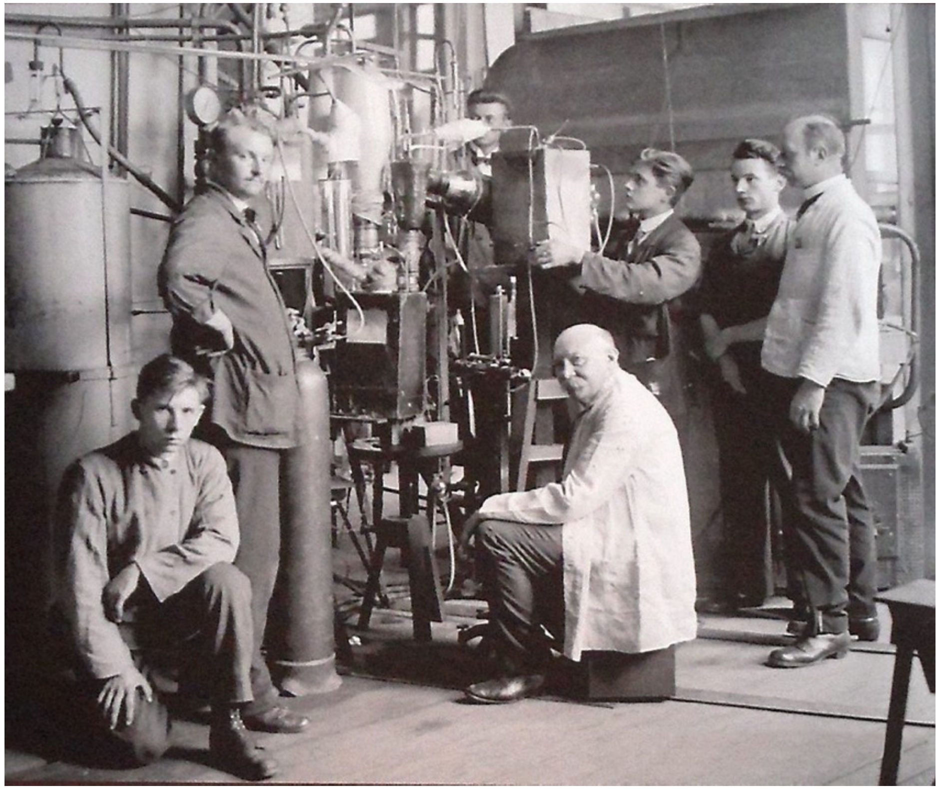
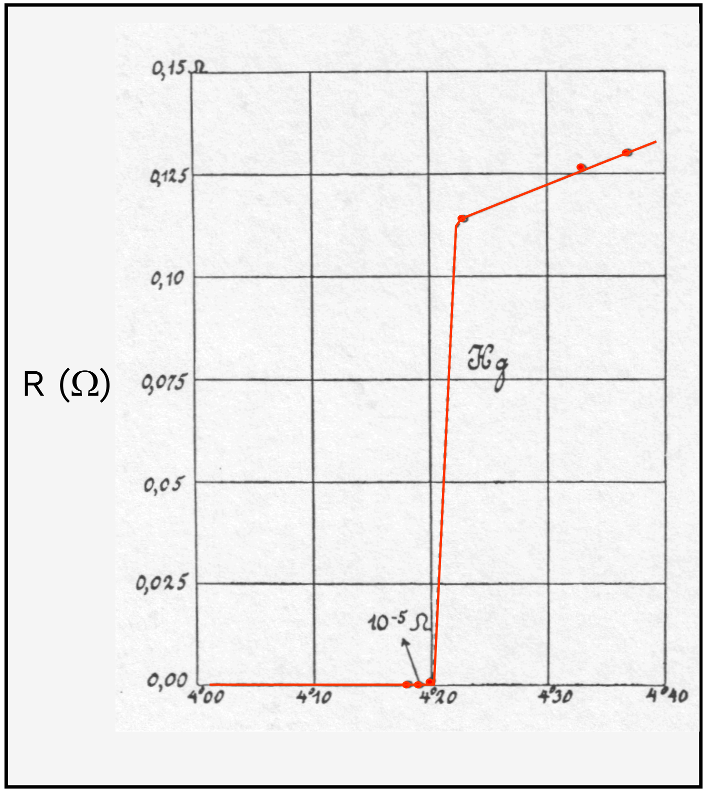
La supraconductivité

La découverte en 1911





La résistance du mercure chute à 0 sous T=4,5K

La supraconductivité

Un courant perpétuel

La supraconductivité

L’effet Meissner : expulsion du champ magnétique

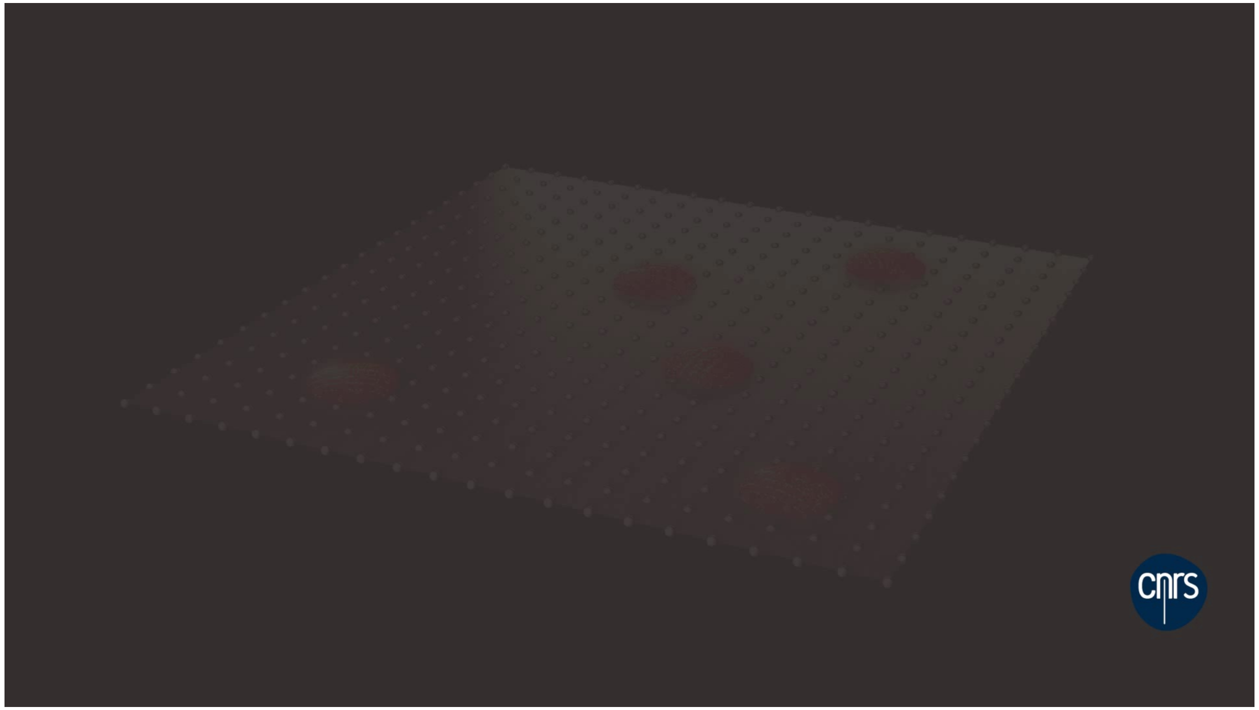
La supraconductivité

L'explication : une condensation quantique

Condensation
de Bose
Einstein

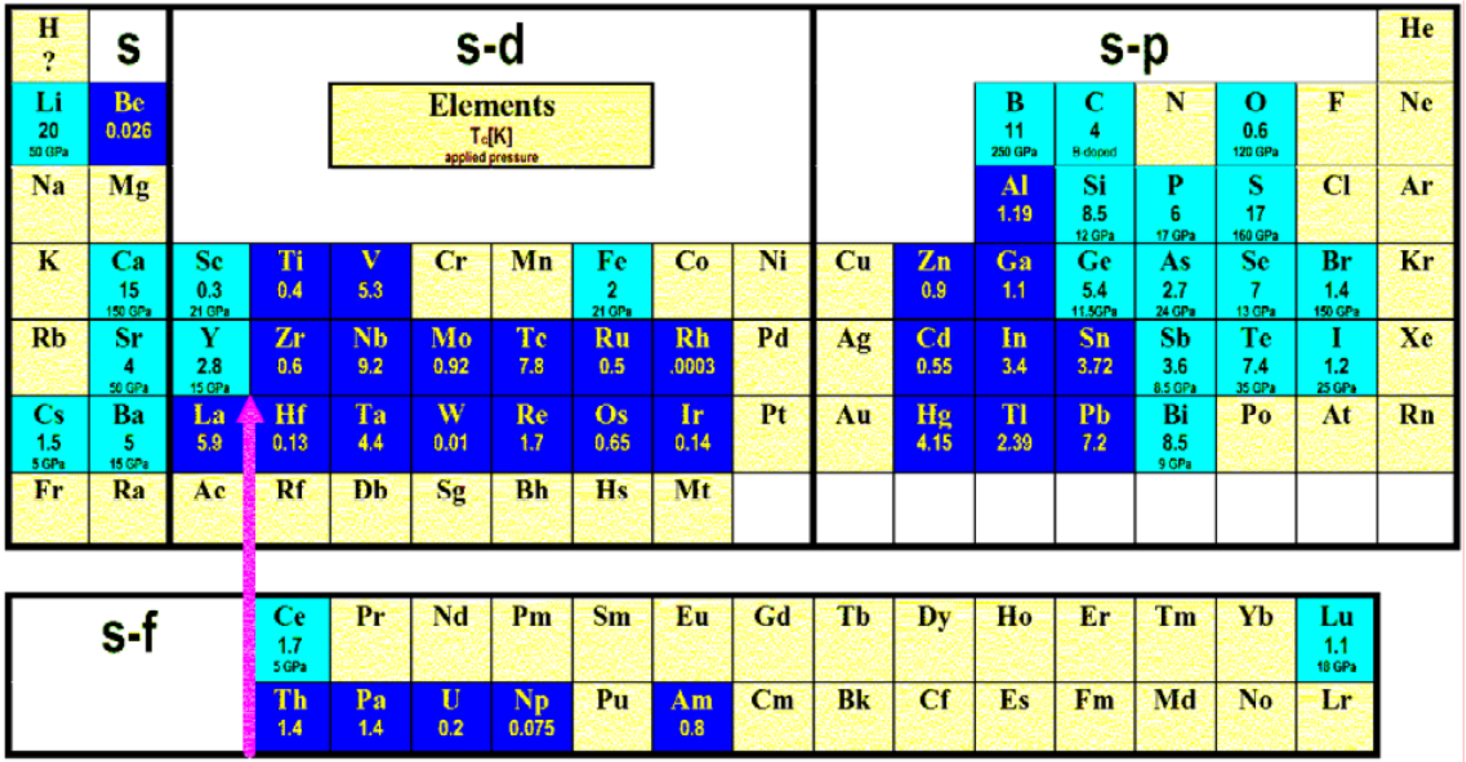
La supraconductivité

La théorie BCS : pour pouvoir condenser, les électrons forment des paires



La supraconductivité

matériaux



H ?	**s**	**s-d**								**s-p**							**He**
Li 20 50 GPa	**Be** 0.026			**Elements** T_c[K] applied pressure								**B** 11 250 GPa	**C** 4 B doped	**N**	**O** 0.6 120 GPa	**F**	**Ne**
Na	**Mg**											**Al** 1.19	**Si** 8.5 12 GPa	**P** 6 17 GPa	**S** 17 160 GPa	**Cl**	**Ar**
K	**Ca** 15 150 GPa	**Sc** 0.3 21 GPa	**Ti** 0.4	**V** 5.3	**Cr**	**Mn**	**Fe** 2 21 GPa	**Co**	**Ni**	**Cu**	**Zn** 0.9	**Ga** 1.1	**Ge** 5.4 11.5GPa	**As** 2.7 24 GPa	**Se** 7 13 GPa	**Br** 1.4 150 GPa	**Kr**
Rb	**Sr** 4 50 GPa	**Y** 2.8 15 GPa	**Zr** 0.6	**Nb** 9.2	**Mo** 0.92	**Tc** 7.8	**Ru** 0.5	**Rh** .0003	**Pd**	**Ag**	**Cd** 0.55	**In** 3.4	**Sn** 3.72	**Sb** 3.6 8.5 GPa	**Te** 7.4 35 GPa	**I** 1.2 25 GPa	**Xe**
Cs 1.5 5 GPa	**Ba** 5 15 GPa	**La** 5.9	**Hf** 0.13	**Ta** 4.4	**W** 0.01	**Re** 1.7	**Os** 0.65	**Ir** 0.14	**Pt**	**Au**	**Hg** 4.15	**Tl** 2.39	**Pb** 7.2	**Bi** 8.5 9 GPa	**Po**	**At**	**Rn**
Fr	**Ra**	**Ac**	**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**									

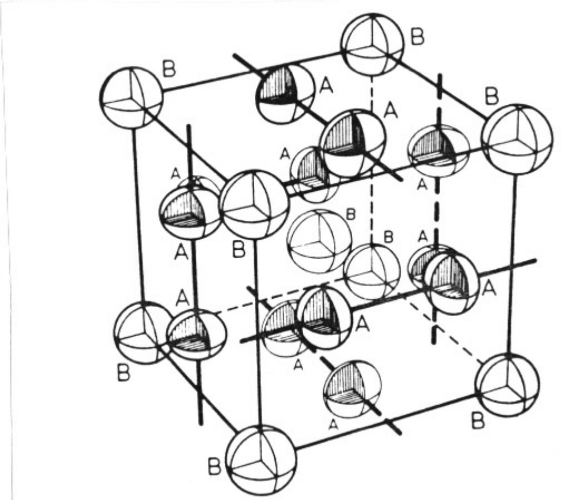
s-f	**Ce** 1.7 5 GPa	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu** 1.1 18 GPa
	Th 1.4	**Pa** 1.4	**U** 0.2	**Np** 0.075	**Pu**	**Am** 0.8	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lr**

supras : tous sauf les jaunes

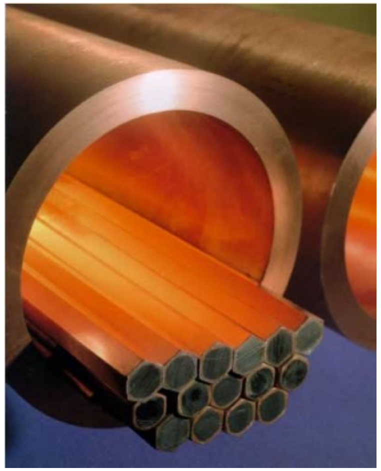
La supraconductivité

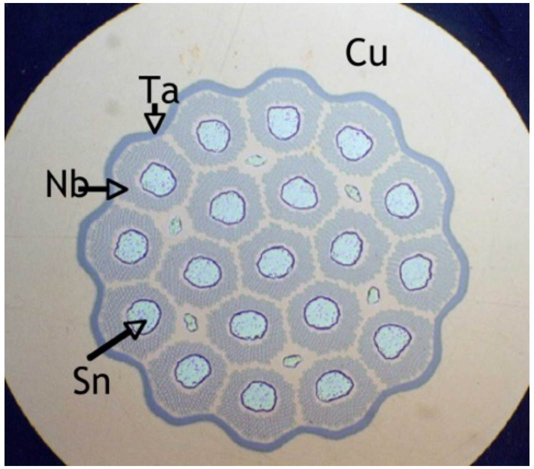
matériaux

Supras les plus utilisés pour les applications : les alliages à base de Niobium : NbTi, Nb^{3}Sn



Nb_3Sn Tc= 18K H_{C2}=24 T





fabrication de fils : avant étirage : assemblage Nb, Sn, Ta, Cu diamètre 20 cm --> après étirage : Nb3Sn diamètre 1mm

La supraconductivité

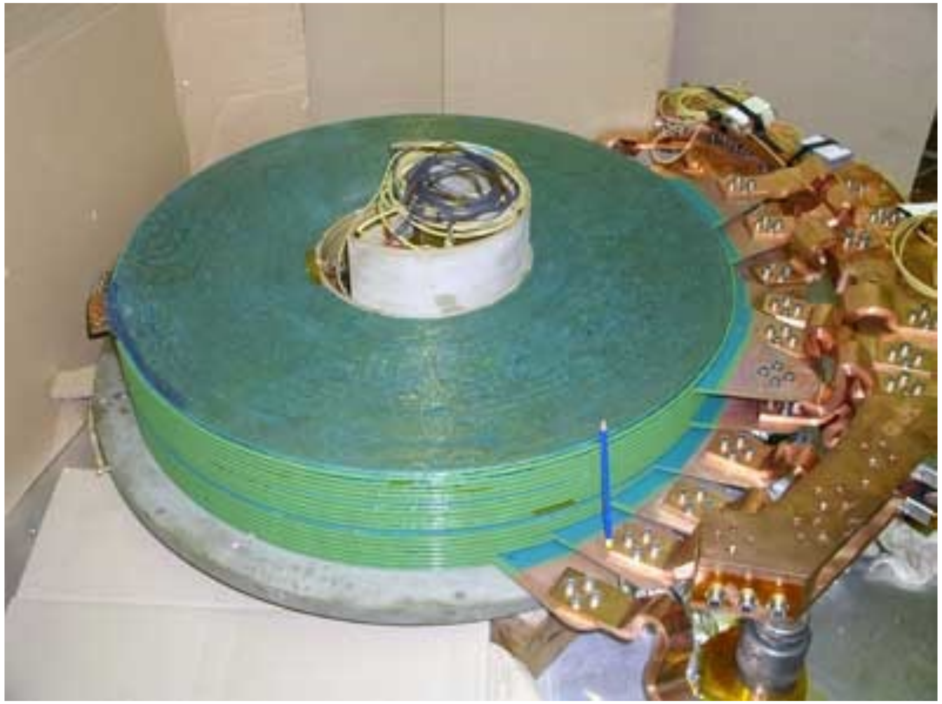
applications : le transport d'électricité

Câbles électriques : plus d'effet Joule, donc plus de pertes.

La supraconductivité

applications : le stockage d’énergie

stockage d’énergie dans des bobines électriques :
plus d’effet Joule, donc plus de pertes.



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La supraconductivité

applications : les champs magnétiques

La supraconductivité

applications : les trains à lévitation

La supraconductivité

applications : l’ordinateur quantique

recherches récentes

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3. la supra sous pression
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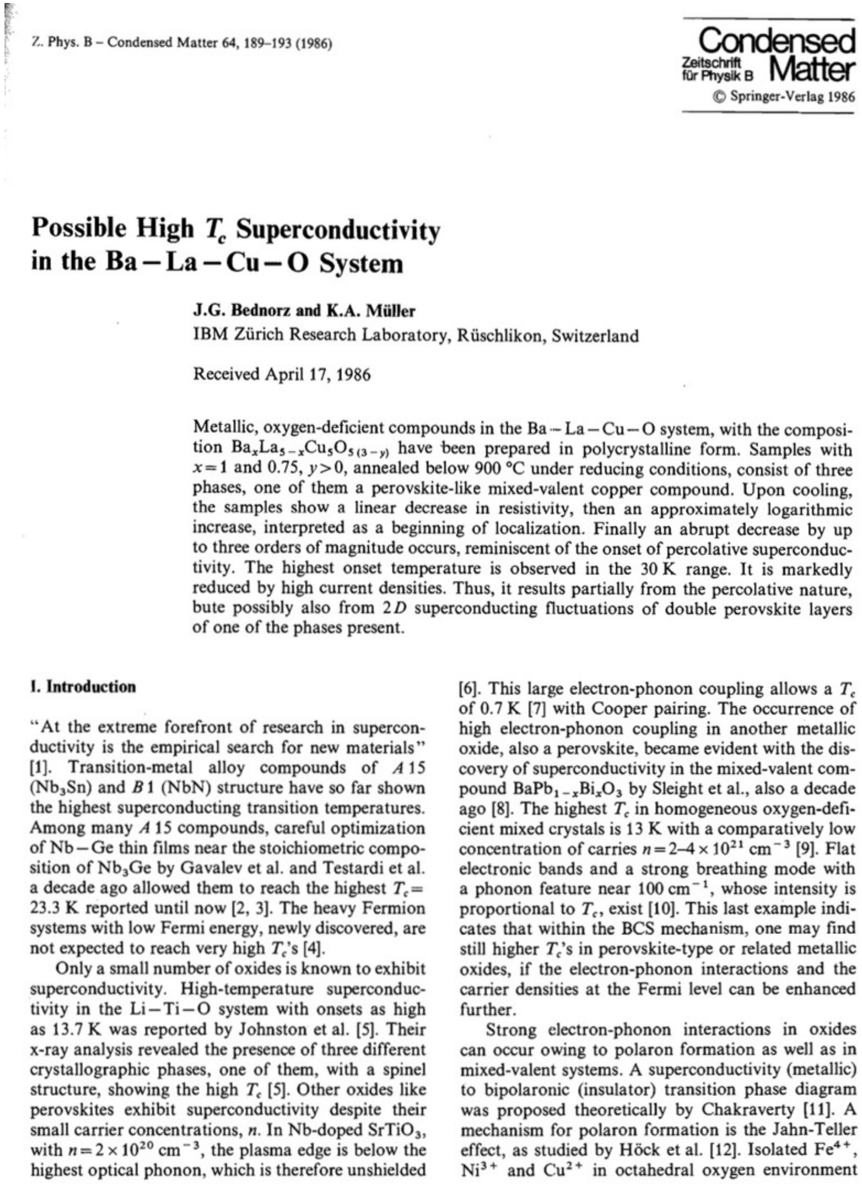
5. un cas de buzz médiatique



Z. Phys. B – Condensed Matter 64, 189–193 (1986)

Condensed Matter
Zeitschrift für Physik B

Possible High T_c Superconductivity in the Ba–La–Cu–O System

J.G. Bednorz and K.A. Müller
IBM Zürich Research Laboratory, Rüschlikon, Switzerland

Received April 17, 1986

Metallic, oxygen-deficient compounds in the Ba–La–Cu–O system, with the composition $Ba_xLa_{5-x}Cu_5O_{5(3-y)}$ have been prepared in polycrystalline form. Samples with $x=1$ and 0.75, $y>0$, annealed below 900 °C under reducing conditions, consist of three phases, one of them a perovskite-like mixed-valent copper compound. Upon cooling, the samples show a linear decrease in resistivity, then an approximately logarithmic increase, interpreted as a beginning of localization. Finally an abrupt decrease by up to three orders of magnitude occurs, reminiscent of the onset of percolative superconductivity. The highest onset temperature is observed in the 30 K range. It is markedly reduced by high current densities. Thus, it results partially from the percolative nature, bute possibly also from $2D$ superconducting fluctuations of double perovskite layers of one of the phases present.

1. Introduction

"At the extreme forefront of research in superconductivity is the empirical search for new materials" [1]. Transition-metal alloy compounds of A15 (Nb_3Sn) and B1 (NbN) structure have so far shown the highest superconducting transition temperatures. Among many A15 compounds, careful optimization of Nb–Ge thin films near the stoichiometric composition of Nb_3Ge by Gavalev et al. and Testardi et al. a decade ago allowed them to reach the highest $T_c = 23.3$ K reported until now [2, 3]. The heavy Fermion systems with low Fermi energy, newly discovered, are not expected to reach very high T_c's [4].

Only a small number of oxides is known to exhibit superconductivity. High-temperature superconductivity in the Li–Ti–O system with onsets as high as 13.7 K was reported by Johnston et al. [5]. Their x-ray analysis revealed the presence of three different crystallographic phases, one of them, with a spinel structure, showing the high T_c [5]. Other oxides like perovskites exhibit superconductivity despite their small carrier concentrations, n. In Nb-doped $SrTiO_3$, with $n=2\times10^{20}$ cm^{-3}, the plasma edge is below the highest optical phonon, which is therefore unshielded [6]. This large electron-phonon coupling allows a T_c of 0.7 K [7] with Cooper pairing. The occurrence of high electron-phonon coupling in another metallic oxide, also a perovskite, became evident with the discovery of superconductivity in the mixed-valent compound $BaPb_{1-x}Bi_xO_3$ by Sleight et al., also a decade ago [8]. The highest T_c in homogeneous oxygen-deficient mixed crystals is 13 K with a comparatively low concentration of carries $n=2$–4×10^{21} cm^{-3} [9]. Flat electronic bands and a strong breathing mode with a phonon feature near 100 cm^{-1}, whose intensity is proportional to T_c, exist [10]. This last example indicates that within the BCS mechanism, one may find still higher T_c's in perovskite-type or related metallic oxides, if the electron-phonon interactions and the carrier densities at the Fermi level can be enhanced further.

Strong electron-phonon interactions in oxides can occur owing to polaron formation as well as in mixed-valent systems. A superconductivity (metallic) to bipolaronic (insulator) transition phase diagram was proposed theoretically by Chakraverty [11]. A mechanism for polaron formation is the Jahn-Teller effect, as studied by Höck et al. [12]. Isolated Fe^{4+}, Ni^{3+} and Cu^{2+} in octahedral oxygen environment

Bednorz et Müller, Z. Phys. B, 189 64 (1986)

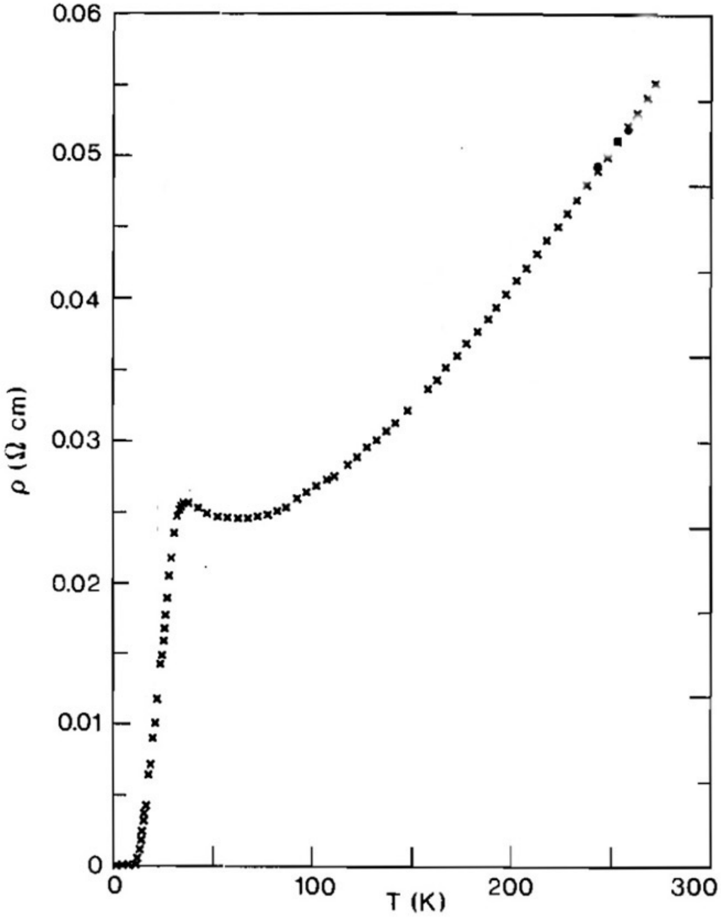
Zürich, Suisse

1986

découvrent une supraconductivité à des températures étonnamment élevées dans des céramiques

La supraconductivité

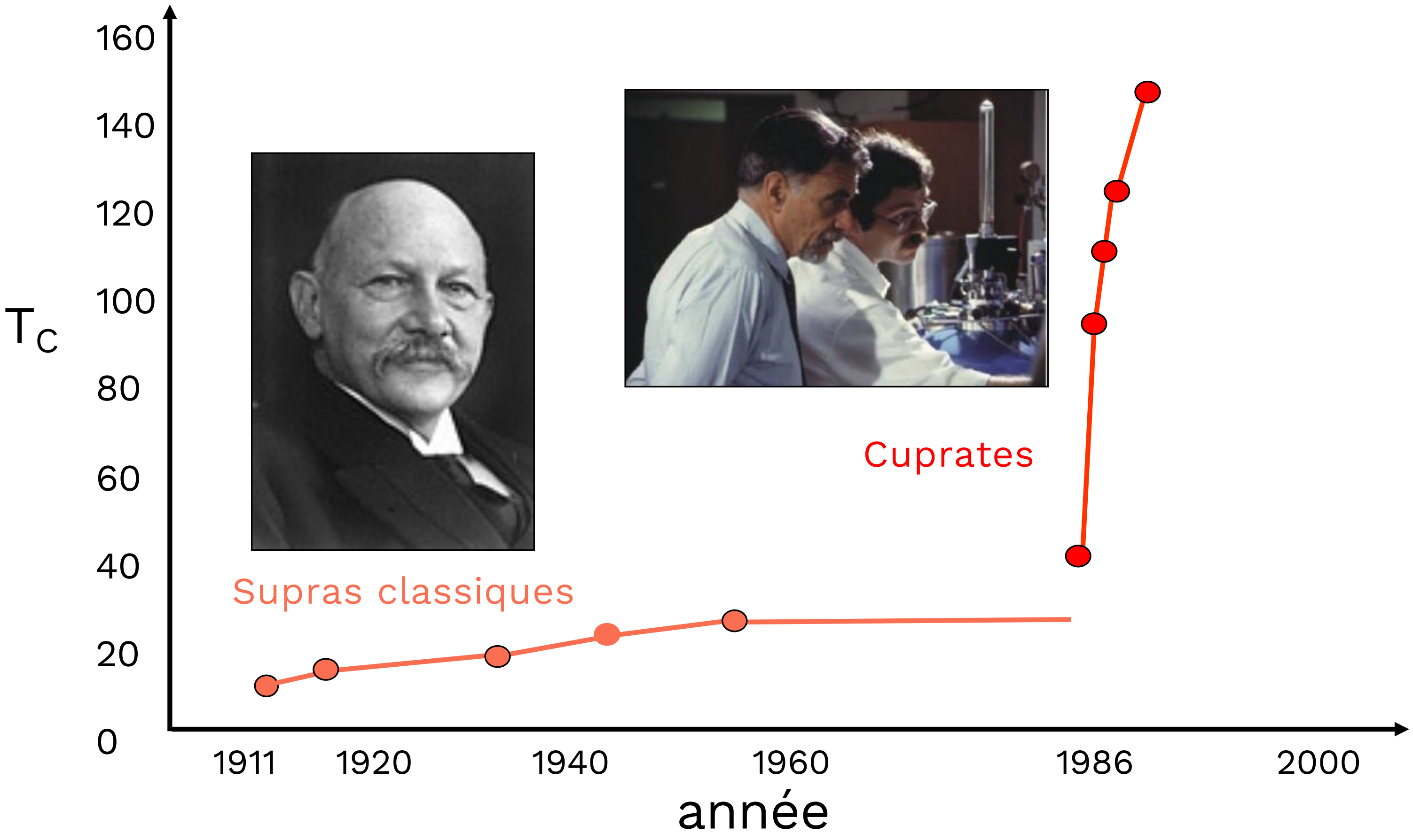
Les nouveaux supraconducteurs cuprates



Müller et Bednorz, 1986

La supraconductivité

Les nouveaux supraconducteurs cuprates



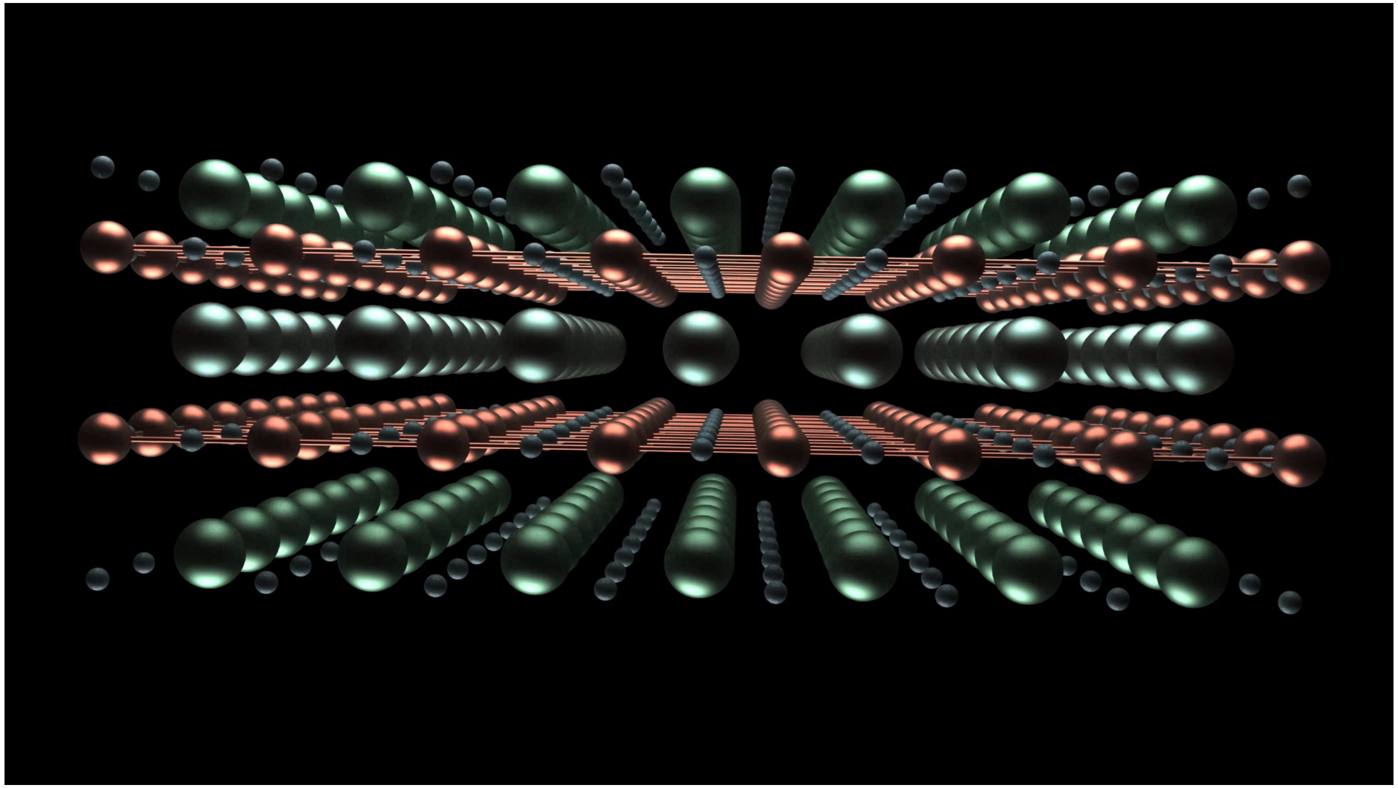
La supraconductivité

Les nouveaux supraconducteurs cuprates

Supras classiques	**Nouveaux supras**
Resistance nulle	pareil
Expulsion magnétique	pareil
Supras sous 20K	Supras jusqu'à 150K
Supras sous 20 Tesla	Supras jusqu'à ~100 Tesla
Electrons par paires	Oui mais plus petites
Via les vibrations des atomes	???

La supraconductivité

Les nouveaux supraconducteurs cuprates : toujours pas compris théoriquement. D’où vient la difficulté ?



recherches récentes

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LETTER

doi:10.1038/nature14964

Conventional superconductivity at 203 kelvin at high pressures in the sulfur hydride system

A. P. Drozdov[1]*, M. I. Eremets[1]*, I. A. Troyan[1], V. Ksenofontov[2] & S. I. Shylin[2]

A superconductor is a material that can conduct electricity without resistance below a superconducting transition temperature, T_c. The highest T_c that has been achieved to date is in the copper oxide system[1]: 133 kelvin at ambient pressure[2] and 164 kelvin at high pressures[3]. As the nature of superconductivity in these materials is still not fully understood (they are not conventional superconductors), the prospects for achieving still higher transition temperatures by this route are not clear. In contrast, the Bardeen–Cooper–Schrieffer theory of conventional superconductivity gives a guide for achieving high T_c with no theoretical upper bound—all that is needed is a favourable combination of high-frequency phonons, strong electron–phonon coupling, and a high density of states[4]. These conditions can in principle be fulfilled for metallic hydrogen and covalent compounds dominated by hydrogen[5,6], as hydrogen atoms provide the necessary high-frequency phonon modes as well as the strong electron–phonon coupling. Numerous calculations support this idea and have predicted transition temperatures in the range 50–235 kelvin for many hydrides[7], but only a moderate T_c of 17 kelvin has been observed experimentally[8]. Here we investigate sulfur hydride[9], where a T_c of 80 kelvin has been predicted[10]. We find that this system transforms to a metal at a pressure of approximately 90 gigapascals. On cooling, we see signatures of superconductivity: a sharp drop of the resistivity to zero and a decrease of the transition temperature with magnetic field, with magnetic susceptibility measurements confirming a T_c of 203 kelvin. Moreover, a pronounced isotope shift of T_c in sulfur deuteride is suggestive of an electron–phonon mechanism of superconductivity that is consistent with the Bardeen–Cooper–Schrieffer scenario. We argue that the phase responsible for high-T_c superconductivity in this system is likely to be H_3S, formed from H_2S by decomposition under pressure. These findings raise hope for the prospects for achieving room-temperature superconductivity in other hydrogen-based materials.

A search for high- (room)-temperature conventional superconductivity is likely to be fruitful, as the Bardeen–Cooper–Schrieffer (BCS) theory in the Eliashberg formulation puts no apparent limits on T_c. Materials with light elements are especially favourable as they provide high frequencies in the phonon spectrum. Indeed, many superconductive materials have been found in this way, but only a moderately high $T_c = 39$ K has been found in this search (in MgB_2; ref. 11).

Ashcroft[5] turned attention to hydrogen, which has very high vibrational frequencies due to the light hydrogen atom and provides a strong electron–phonon interaction. Further calculations showed that metallic hydrogen should be a superconductor with a very high T_c of about 100–240 K for molecular hydrogen, and of 300–350 K in the atomic phase at 500 GPa (ref. 12). However, superconductivity in pure hydrogen has not yet been found, even though a conductive and probably semimetallic state of hydrogen has been recently produced[13]. Hydrogen-dominated materials such as covalent hydrides SiH_4, SnH_4, and so on might also be good candidates for showing high-T_c superconductivity[6]. Similarly to pure hydrogen, they have high Debye temperatures. Moreover, heavier elements might be beneficial as they contribute to the low frequencies that enhance electron–phonon coupling. Importantly, lower pressures are required to metallize hydrides in comparison to pure hydrogen. Ashcroft's general idea was supported in numerous calculations[7,10] predicting high values of T_c for many hydrides. So far only a low T_c (~17 K) has been observed experimentally[8].

For the present study we selected H_2S, because it is relatively easy to handle and is predicted to transform to a metal and a superconductor at a low pressure $P \approx 100$ GPa with a high $T_c \approx 80$ K (ref. 10). Experimentally, H_2S is known as a typical molecular compound with a rich phase diagram[14]. At about 96 GPa, hydrogen sulphide transforms to a metal[15]. The transformation is complicated by the partial dissociation of H_2S and the appearance of elemental sulfur at $P > 27$ GPa at room temperature, and at higher pressures at lower temperatures[14]. Therefore, the metallization of hydrogen sulphide can be explained by elemental sulfur, which is known to become metallic above 95 GPa (ref. 16). No experimental studies of hydrogen sulphide are known above 100 GPa.

In a typical experiment, we performed loading and the initial pressure increase at temperatures of ~200 K; this is essential for obtaining a good sample (Methods). The Raman spectra of H_2S and D_2S were measured as the pressure was increased, and were in general agreement with the literature data[17,18] (Extended Data Fig. 1). The sample starts to conduct at $P \approx 50$ GPa. At this pressure it is a semiconductor, as shown by the temperature dependence of the resistance and pronounced photoconductivity. At 90–100 GPa the resistance drops further, and the temperature dependence becomes metallic. No photoconductive response is observed in this state. It is a poor metal—its resistivity at ~100 K is $\rho \approx 3 \times 10^{-5}$ ohm m at 110 GPa and $\rho \approx 3 \times 10^{-7}$ ohm m at ~200 GPa.

During the cooling of the metal at pressures of about 100 GPa (Fig. 1a) the resistance abruptly drops by three to four orders of magnitude, indicating a transition to the superconducting state. At the next increase of pressure at low temperatures of $T < 100$ K, T_c steadily increases with pressure. However, at pressures of >160 GPa, T_c increases sharply (Fig. 1b). As higher temperatures of 150–250 K were involved in this pressure range, we supposed that the increase of T_c and the decrease of sample resistance during warming (Fig. 1a) could indicate a possible kinetic-controlled phase transformation. Therefore in further experiments, after loading and after the initial pressure increase at 200 K, we annealed all samples by heating them to room temperature (or above) at pressures of >~150 GPa (Fig. 2a, see also Extended Data Fig. 2). This allowed us to obtain stable results, to compare different isotopes, to obtain the dependence of T_c on pressure and magnetic field, and to prove the existence of superconductivity in our samples as follows. (We note that additional information on experimental conditions are given in the appropriate figure legends.)

---

[1] Max-Planck-Institut für Chemie, Hahn-Meitner-Weg 1, 55128 Mainz, Germany. [2] Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg-Universität Mainz, Staudingerweg 9, 55099 Mainz, Germany.

*These authors contributed equally to this work.

Drozdov et al., Nature, 2015

Mainz (Mayence), Allemagne

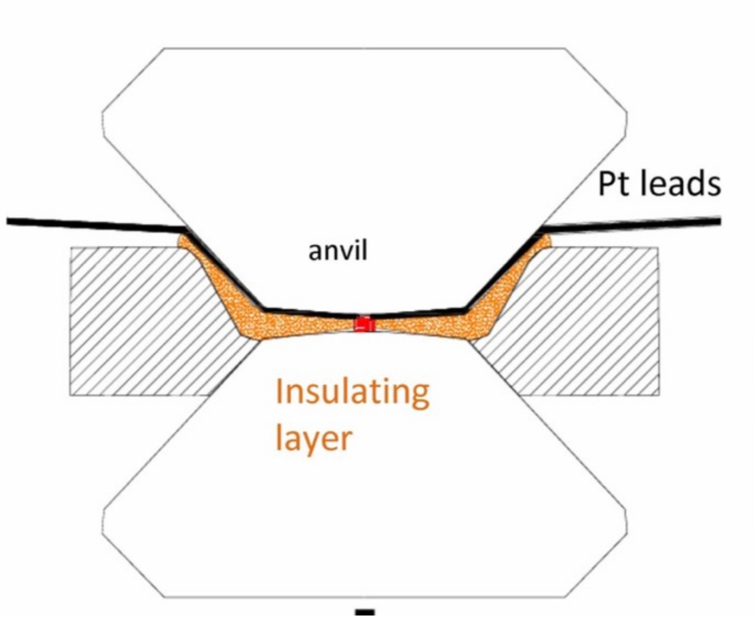
2015

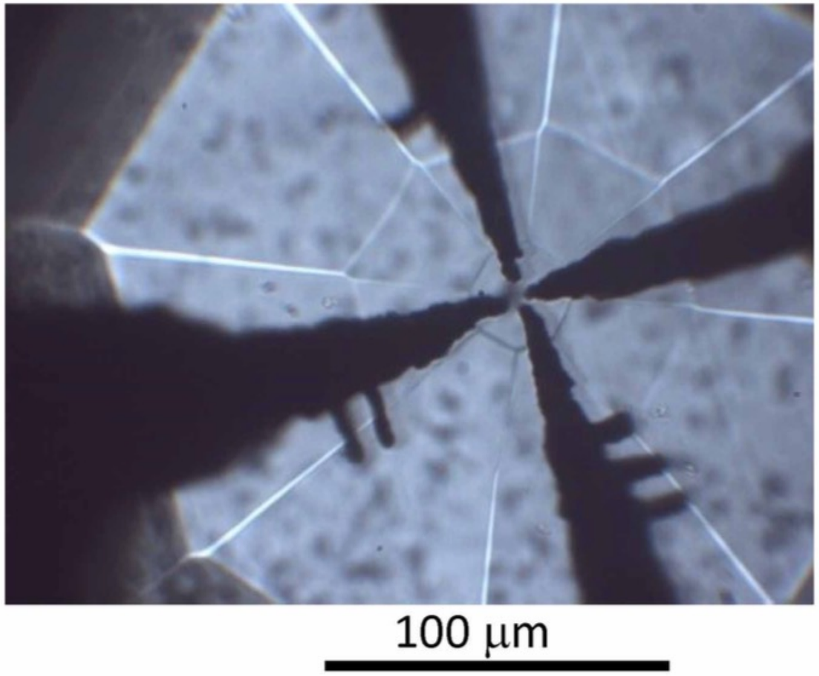
découvrent une supraconductivité record dans des gaz sous pression

La supraconductivité sous pression

La découverte

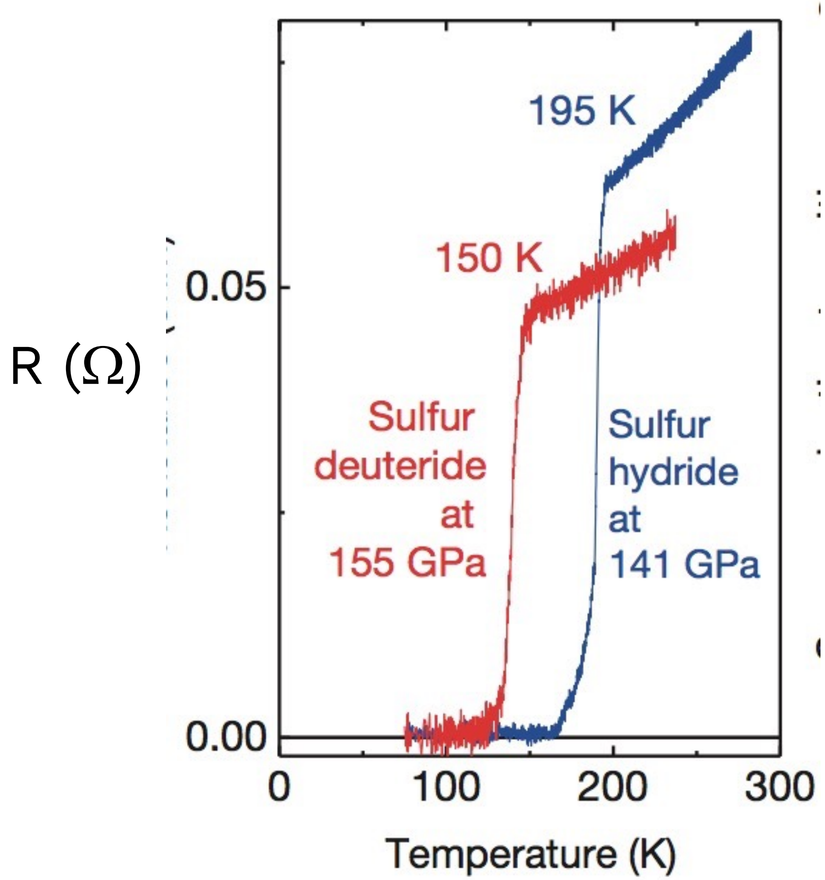
mise sous pression de gaz sous enclume diamant :

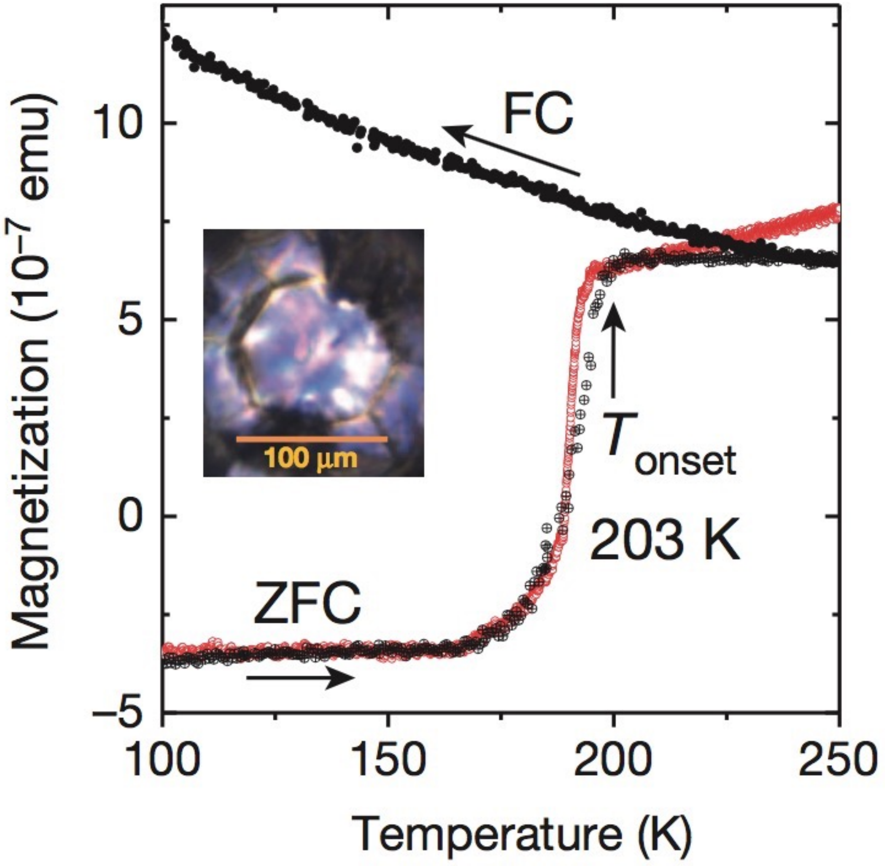




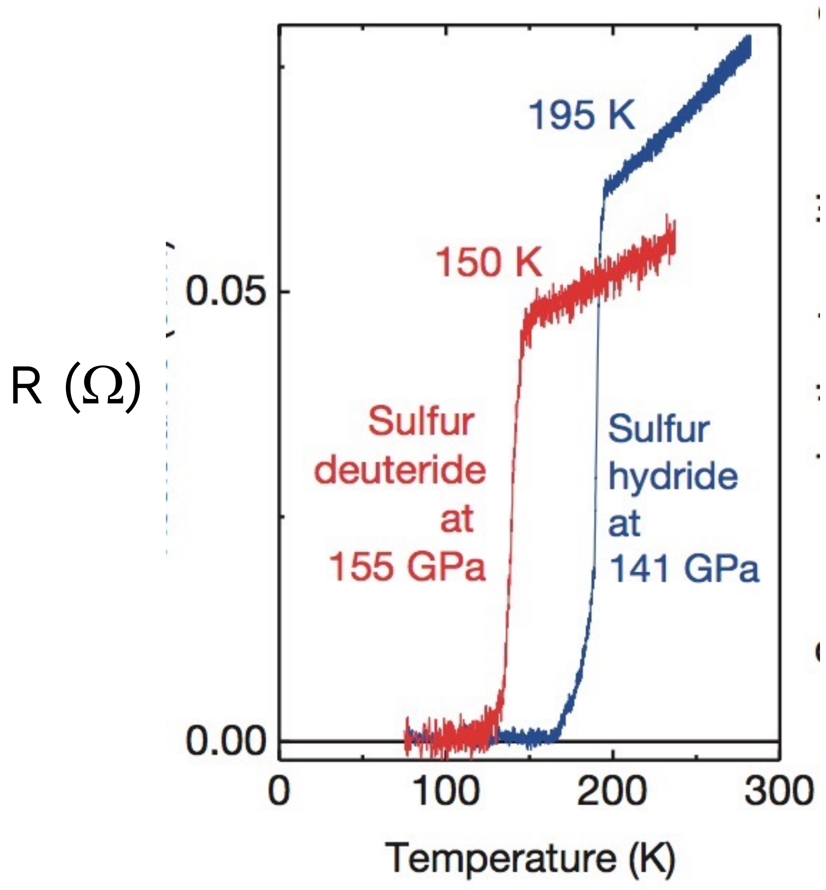
La supraconductivité sous pression

Apparition d’une supra sous T=195K





La supraconductivité sous pression



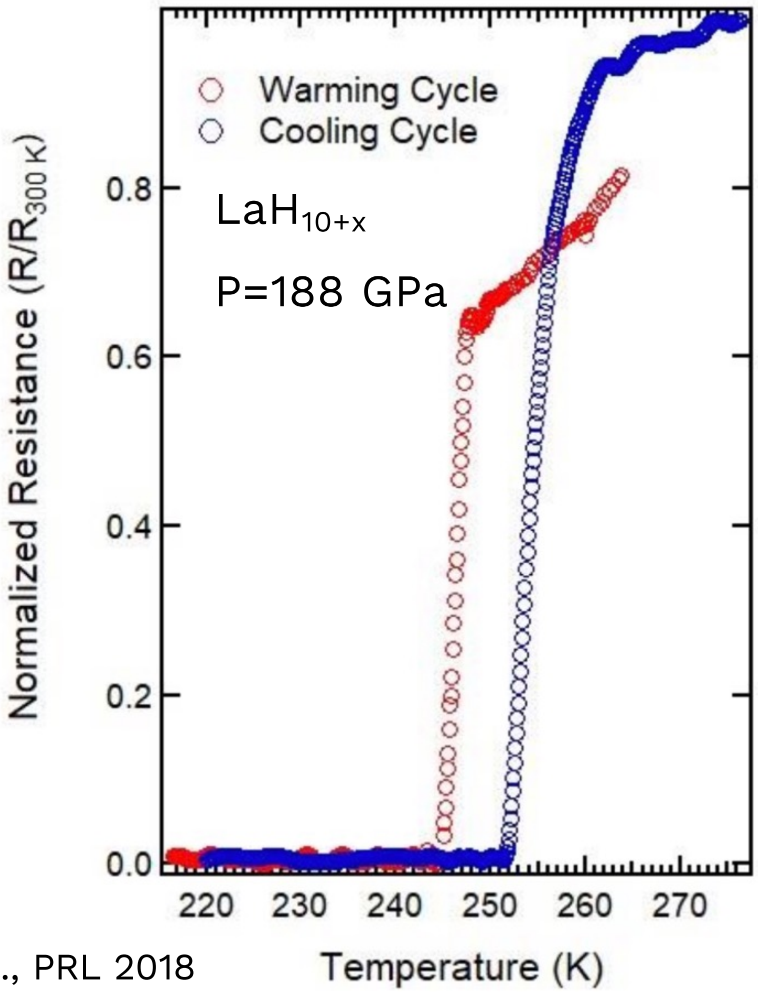
Tc dépend de la masse des atomes en :

$$T_C \sim \frac{1}{\sqrt{M_{atome}}}$$

→ supraconductivité classique liée à la vibration des atomes (effet isotopique)

La supraconductivité sous pression

On atteint T_c=260K
dans des composés au Lanthane



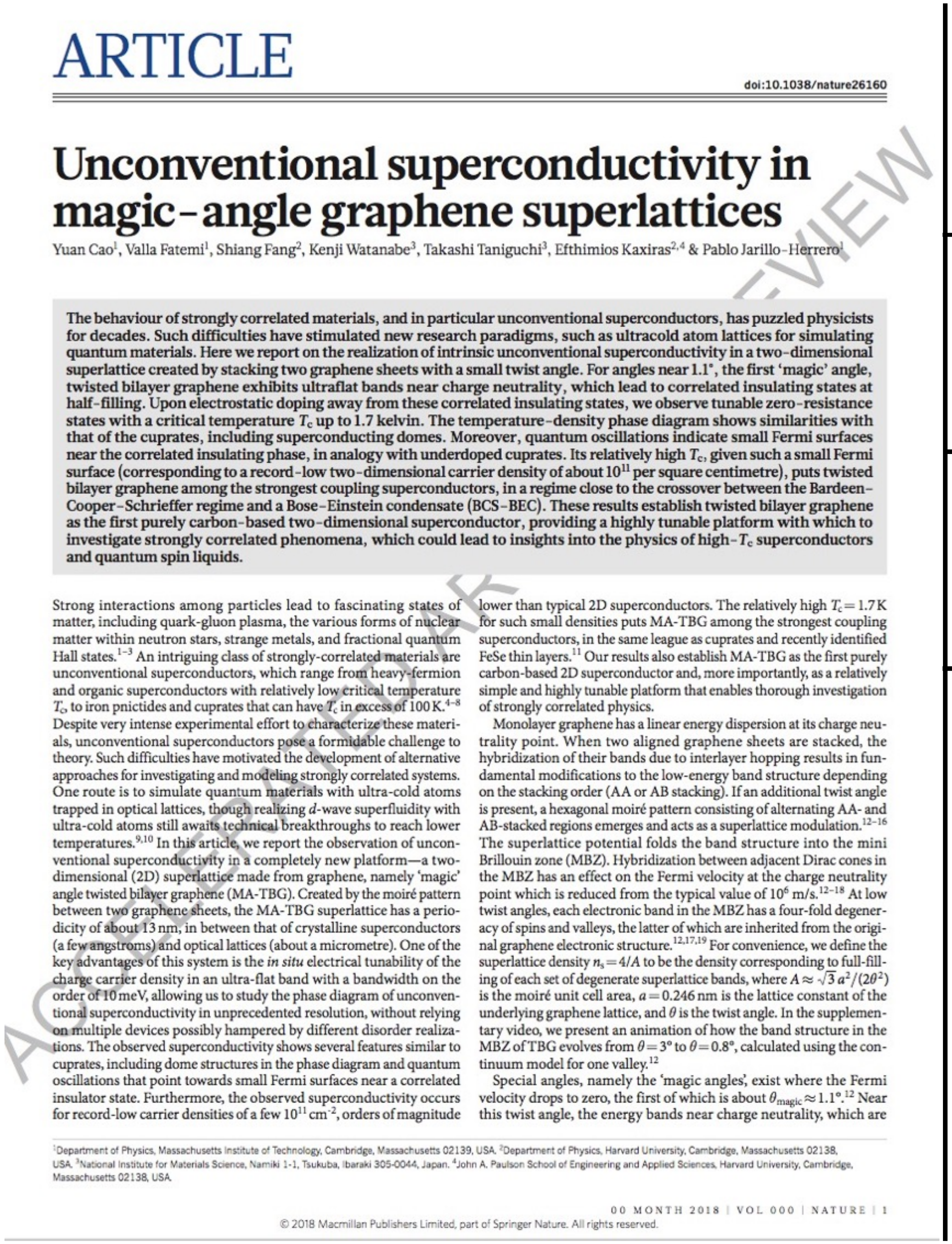
LaH_{10+x}

P=188 GPa

Somayazulu et al., PRL 2018

recherches récentes

1. guider la foudre
2. la supraconductivité à haute température
3. la supra sous pression
4. **la supra dans le graphène**
5. un cas de buzz médiatique



ARTICLE

doi:10.1038/nature26160

Unconventional superconductivity in magic-angle graphene superlattices

Yuan Cao[1], Valla Fatemi[1], Shiang Fang[2], Kenji Watanabe[3], Takashi Taniguchi[3], Efthimios Kaxiras[2,4] & Pablo Jarillo-Herrero[1]

The behaviour of strongly correlated materials, and in particular unconventional superconductors, has puzzled physicists for decades. Such difficulties have stimulated new research paradigms, such as ultracold atom lattices for simulating quantum materials. Here we report on the realization of intrinsic unconventional superconductivity in a two-dimensional superlattice created by stacking two graphene sheets with a small twist angle. For angles near 1.1°, the first 'magic' angle, twisted bilayer graphene exhibits ultraflat bands near charge neutrality, which lead to correlated insulating states at half-filling. Upon electrostatic doping away from these correlated insulating states, we observe tunable zero-resistance states with a critical temperature T_c up to 1.7 kelvin. The temperature-density phase diagram shows similarities with that of the cuprates, including superconducting domes. Moreover, quantum oscillations indicate small Fermi surfaces near the correlated insulating phase, in analogy with underdoped cuprates. Its relatively high T_c, given such a small Fermi surface (corresponding to a record-low two-dimensional carrier density of about 10^{11} per square centimetre), puts twisted bilayer graphene among the strongest coupling superconductors, in a regime close to the crossover between the Bardeen–Cooper–Schrieffer regime and a Bose–Einstein condensate (BCS–BEC). These results establish twisted bilayer graphene as the first purely carbon-based two-dimensional superconductor, providing a highly tunable platform with which to investigate strongly correlated phenomena, which could lead to insights into the physics of high-T_c superconductors and quantum spin liquids.

Strong interactions among particles lead to fascinating states of matter, including quark-gluon plasma, the various forms of nuclear matter within neutron stars, strange metals, and fractional quantum Hall states.[1–3] An intriguing class of strongly-correlated materials are unconventional superconductors, which range from heavy-fermion and organic superconductors with relatively low critical temperature T_c, to iron pnictides and cuprates that can have T_c in excess of 100 K.[4–8] Despite very intense experimental effort to characterize these materials, unconventional superconductors pose a formidable challenge to theory. Such difficulties have motivated the development of alternative approaches for investigating and modeling strongly correlated systems. One route is to simulate quantum materials with ultra-cold atoms trapped in optical lattices, though realizing *d*-wave superfluidity with ultra-cold atoms still awaits technical breakthroughs to reach lower temperatures.[9,10] In this article, we report the observation of unconventional superconductivity in a completely new platform—a two-dimensional (2D) superlattice made from graphene, namely 'magic' angle twisted bilayer graphene (MA-TBG). Created by the moiré pattern between two graphene sheets, the MA-TBG superlattice has a periodicity of about 13 nm, in between that of crystalline superconductors (a few angstroms) and optical lattices (about a micrometre). One of the key advantages of this system is the *in situ* electrical tunability of the charge carrier density in an ultra-flat band with a bandwidth on the order of 10 meV, allowing us to study the phase diagram of unconventional superconductivity in unprecedented resolution, without relying on multiple devices possibly hampered by different disorder realizations. The observed superconductivity shows several features similar to cuprates, including dome structures in the phase diagram and quantum oscillations that point towards small Fermi surfaces near a correlated insulator state. Furthermore, the observed superconductivity occurs for record-low carrier densities of a few 10^{11} cm^{-2}, orders of magnitude lower than typical 2D superconductors. The relatively high $T_c = 1.7$ K for such small densities puts MA-TBG among the strongest coupling superconductors, in the same league as cuprates and recently identified FeSe thin layers.[11] Our results also establish MA-TBG as the first purely carbon-based 2D superconductor and, more importantly, as a relatively simple and highly tunable platform that enables thorough investigation of strongly correlated physics.

Monolayer graphene has a linear energy dispersion at its charge neutrality point. When two aligned graphene sheets are stacked, the hybridization of their bands due to interlayer hopping results in fundamental modifications to the low-energy band structure depending on the stacking order (AA or AB stacking). If an additional twist angle is present, a hexagonal moiré pattern consisting of alternating AA- and AB-stacked regions emerges and acts as a superlattice modulation.[12–16] The superlattice potential folds the band structure into the mini Brillouin zone (MBZ). Hybridization between adjacent Dirac cones in the MBZ has an effect on the Fermi velocity at the charge neutrality point which is reduced from the typical value of 10^6 m/s.[12–18] At low twist angles, each electronic band in the MBZ has a four-fold degeneracy of spins and valleys, the latter of which are inherited from the original graphene electronic structure.[12,17,19] For convenience, we define the superlattice density $n_s = 4/A$ to be the density corresponding to full-filling of each set of degenerate superlattice bands, where $A \approx \sqrt{3}\,a^2/(2\theta^2)$ is the moiré unit cell area, $a = 0.246$ nm is the lattice constant of the underlying graphene lattice, and θ is the twist angle. In the supplementary video, we present an animation of how the band structure in the MBZ of TBG evolves from $\theta = 3°$ to $\theta = 0.8°$, calculated using the continuum model for one valley.[12]

Special angles, namely the 'magic angles', exist where the Fermi velocity drops to zero, the first of which is about $\theta_{\mathrm{magic}} \approx 1.1°$.[12] Near this twist angle, the energy bands near charge neutrality, which are

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Y.Cao et al., Nature 2018

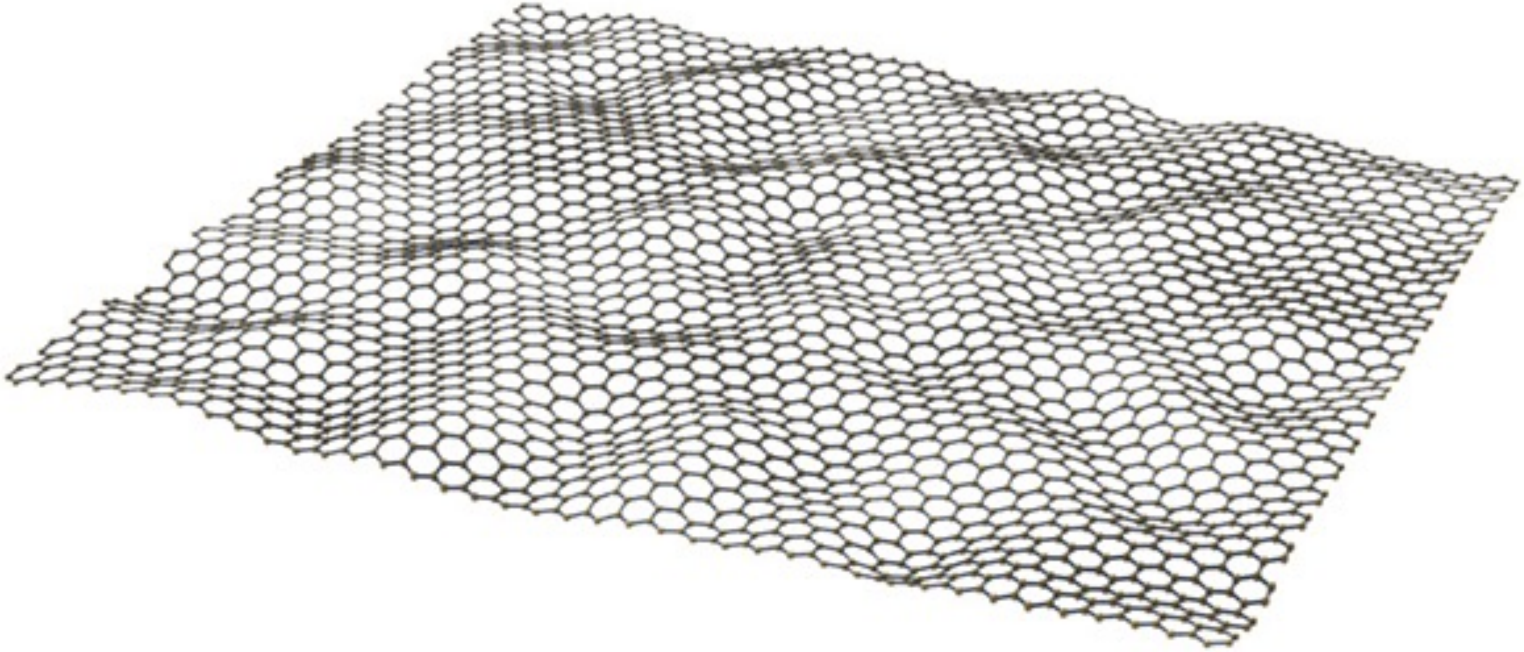
MIT, USA

2018

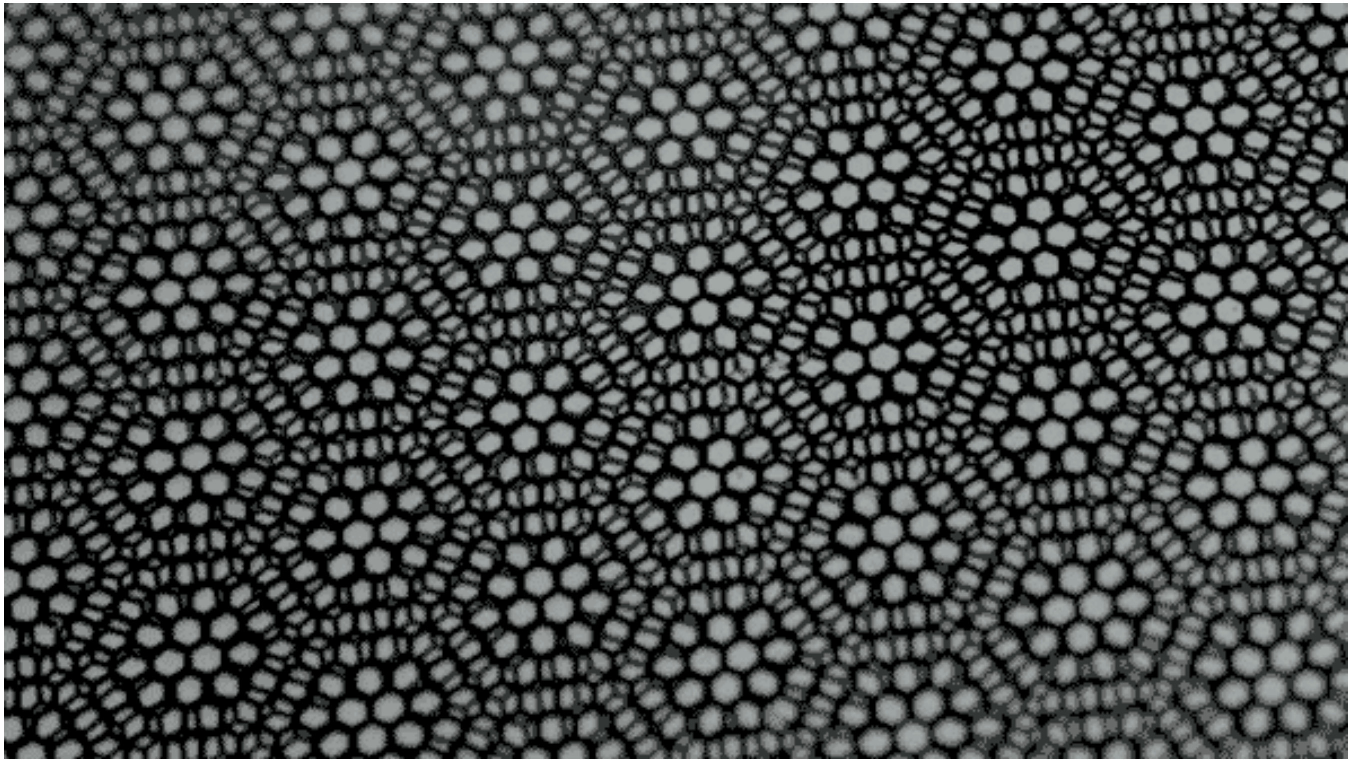
découvrent une supraconductivité dans des composés à base de graphène à des angles « magiques »

La supraconductivité dans le graphène

le graphène : monocouche de carbone.
N’est pas supraconducteur.



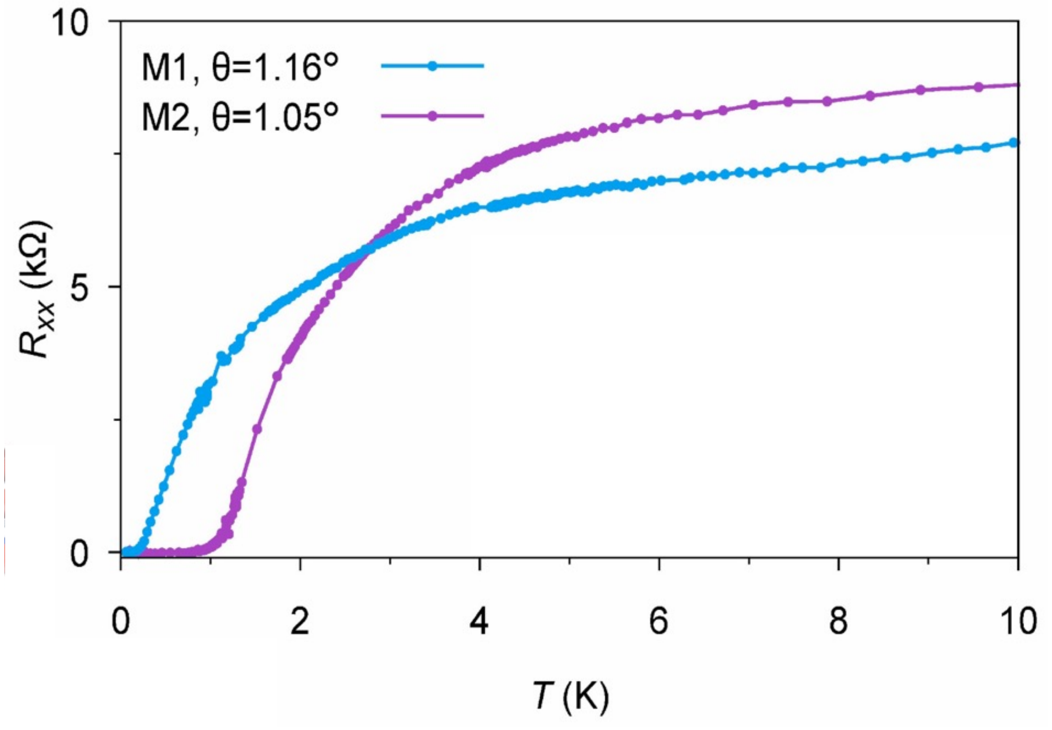
La supraconductivité dans le graphène



On fait tourner une couche de graphène sur une autre

La supraconductivité dans le graphène

Quand on fait tourner à 1,1°, il apparaît de la supraconductivité !



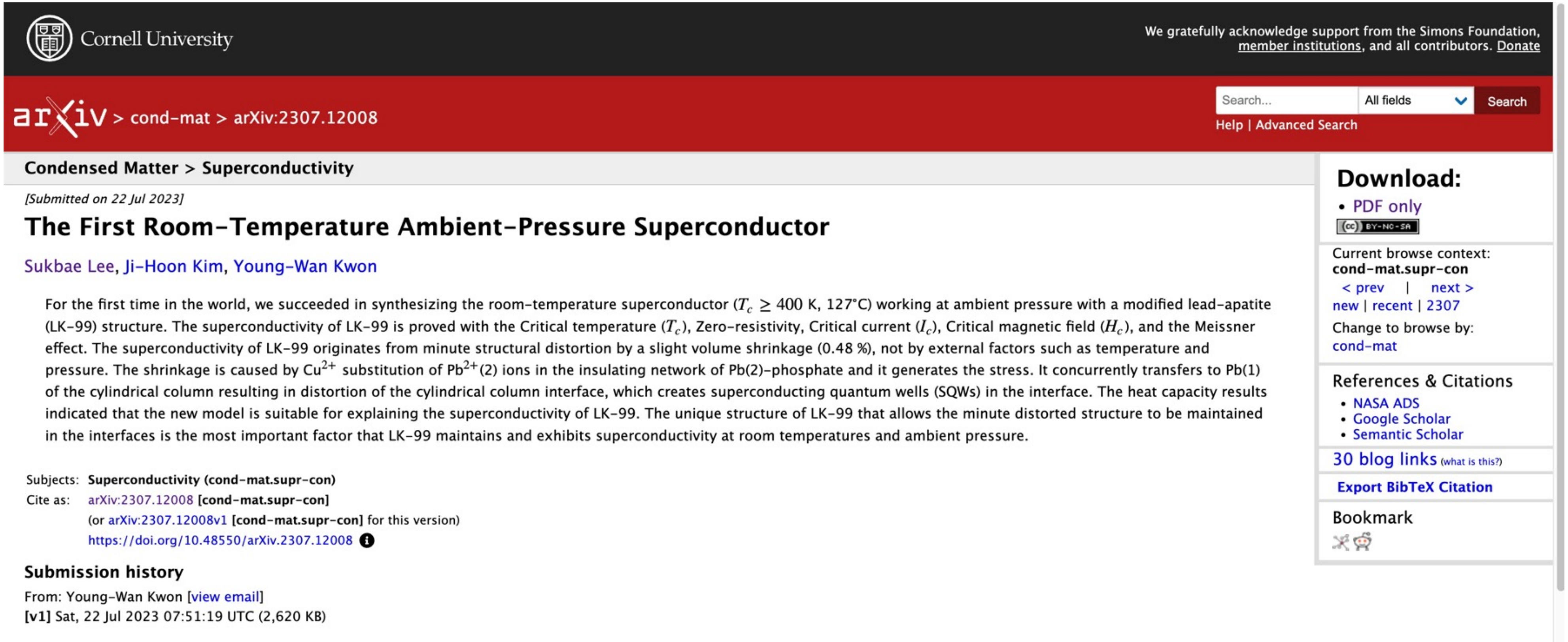
→ lié à la structure électronique du système.

recherches récentes

1. guider la foudre
2. la supraconductivité à haute température
3. la supra sous pression
4. la supra dans le graphène
5. **un cas de buzz médiatique**

Un cas de buzz médiatique autour de la supra

Le 22 juillet 2023...



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.

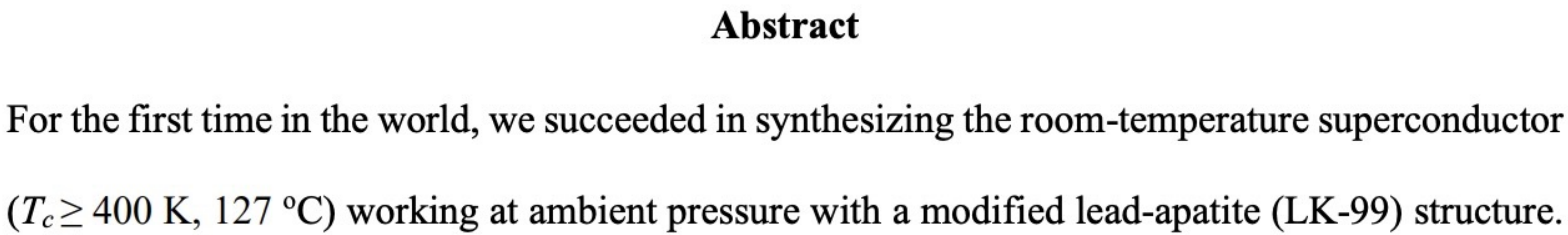
Subjects: **Superconductivity (cond-mat.supr-con)**
Cite as: arXiv:2307.12008 **[cond-mat.supr-con]**
(or arXiv:2307.12008v1 **[cond-mat.supr-con]** for this version)
https://doi.org/10.48550/arXiv.2307.12008

Submission history

From: Young-Wan Kwon [view email]
[v1] Sat, 22 Jul 2023 07:51:19 UTC (2,620 KB)

Un cas de buzz médiatique autour de la supra

Le 22 juillet 2023…



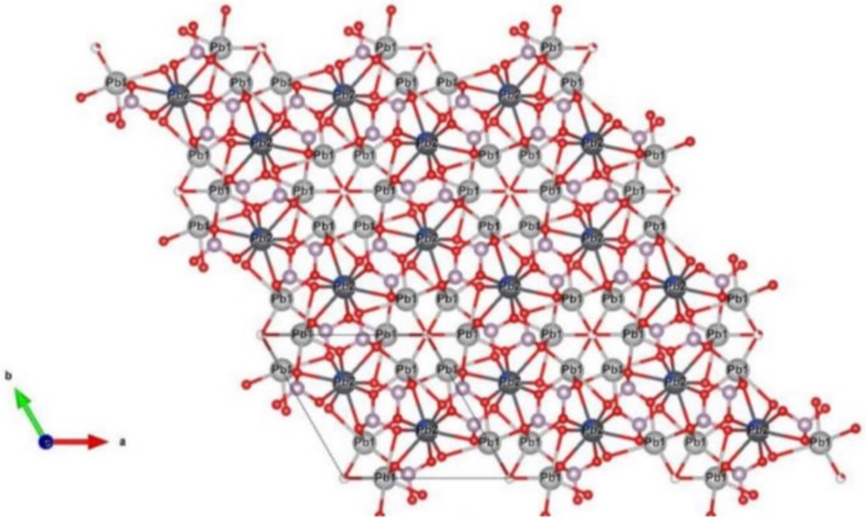
Abstract

For the first time in the world, we succeeded in synthesizing the room-temperature superconductor ($T_c \geq 400$ K, 127 ºC) working at ambient pressure with a modified lead-apatite (LK-99) structure.

Un cas de buzz médiatique autour de la supra

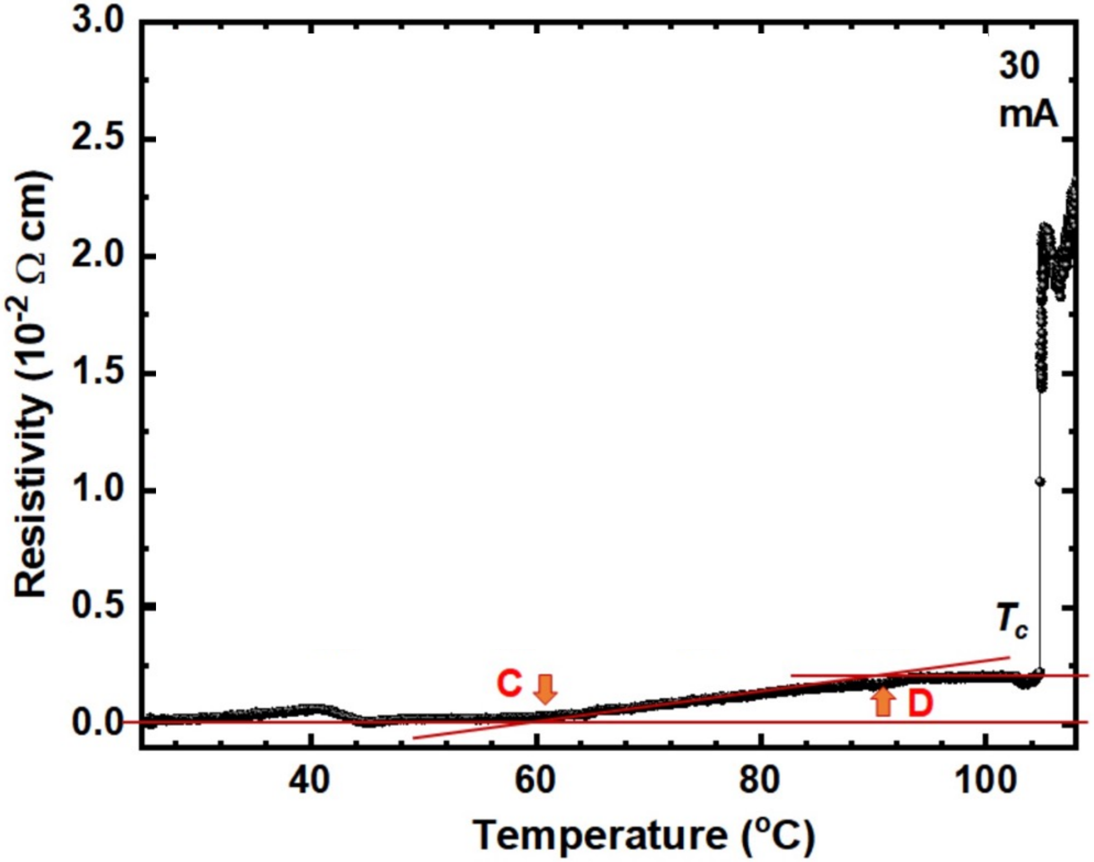
Le 22 juillet 2023…

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



Un cas de buzz médiatique autour de la supra

Le 22 juillet 2023...



Un cas de buzz médiatique autour de la supra

Le 22 juillet 2023...

Un cas de buzz médiatique autour de la supra

quelques heures plus tard, le buzz !

What Is L

What Is LK-99: This Material Could Change Everything - Nanografi

This Material Could Change Everything

SCIENCES ET AVENIR La Recherche

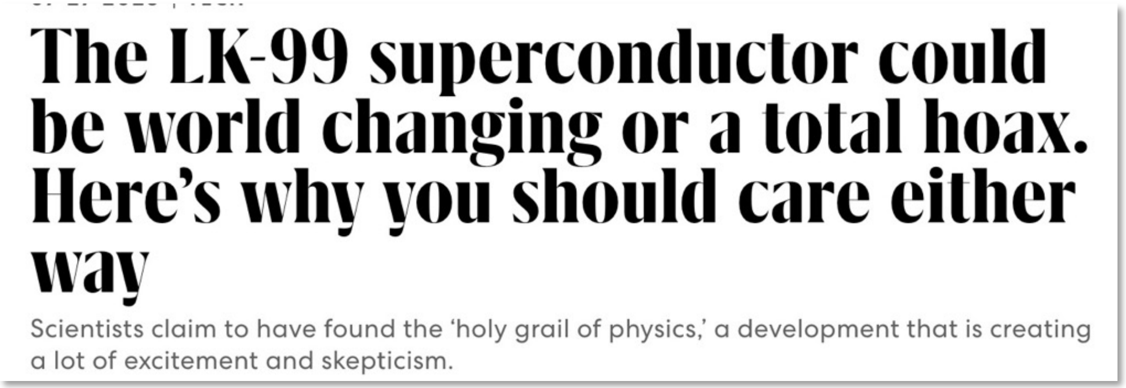
LK-99 : "Un supraconducteur à température et pression ambiantes, c'est la promesse de révolutionner le transport de l'énergie"

Le Figaro

LK-99 : le matériau «révolutionnaire» …

Ask Ethan: Is LK-99 the holy grail of superconductors?

Recent claims put LK-99 as the first room temperature, ambient pressure superconductor ever. Has the game changed, or is it merely hype?

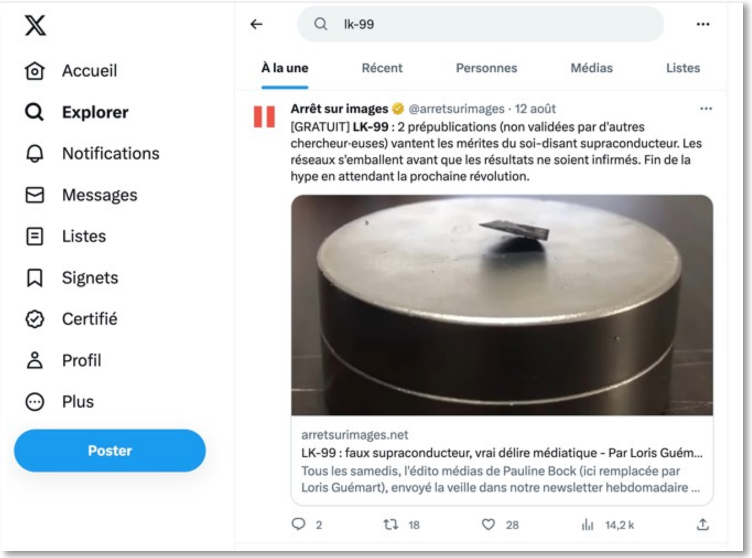


The LK-99 superconductor could be world changing or a total hoax. Here's why you should care either way

Scientists claim to have found the 'holy grail of physics,' a development that is creating a lot of excitement and skepticism.

Un cas de buzz médiatique autour de la supra

Les lieux de discussion : pas comme d’habitude



Arrêt sur images @arretsurimages · 12 août

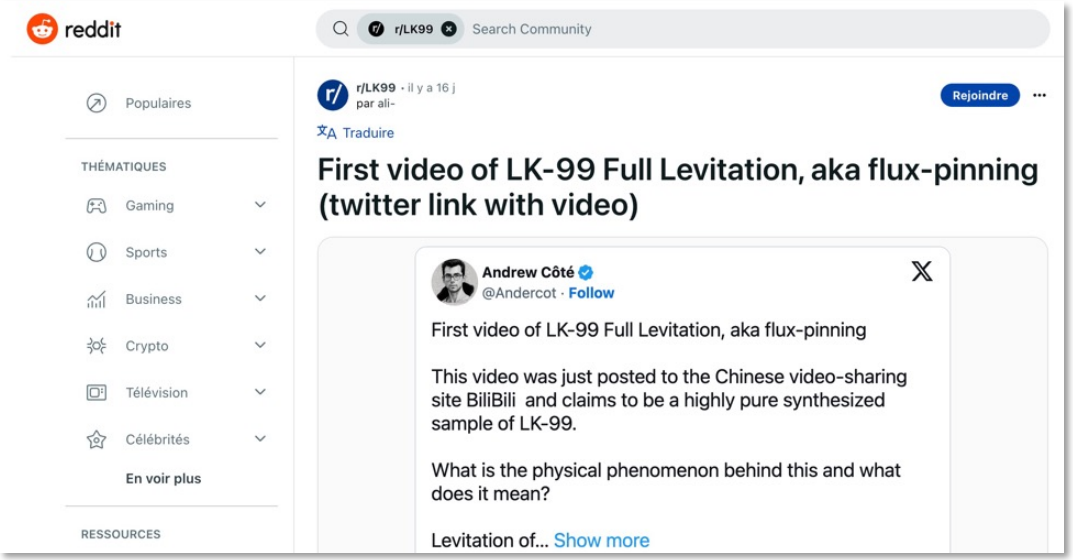
[GRATUIT] **LK-99** : 2 prépublications (non validées par d'autres chercheur-euses) vantent les mérites du soi-disant supraconducteur. Les réseaux s'emballent avant que les résultats ne soient infirmés. Fin de la hype en attendant la prochaine révolution.

arretsurimages.net

LK-99 : faux supraconducteur, vrai délire médiatique - Par Loris Guém...

Tous les samedis, l'édito médias de Pauline Bock (ici remplacée par Loris Guémart), envoyé la veille dans notre newsletter hebdomadaire ...

2 · 18 · 28 · 14,2 k



r/LK99 · il y a 16 j
par ali-

First video of LK-99 Full Levitation, aka flux-pinning (twitter link with video)

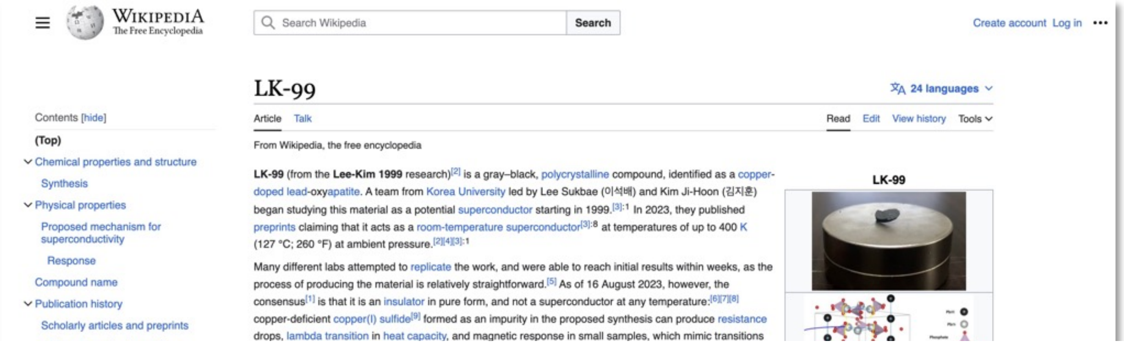
Andrew Côté @Andercot · Follow

First video of LK-99 Full Levitation, aka flux-pinning

This video was just posted to the Chinese video-sharing site BiliBili and claims to be a highly pure synthesized sample of LK-99.

What is the physical phenomenon behind this and what does it mean?

Levitation of... Show more



LK-99

From Wikipedia, the free encyclopedia

LK-99 (from the **Lee-Kim 1999** research)[2] is a gray–black, polycrystalline compound, identified as a copper-doped lead-oxyapatite. A team from Korea University led by Lee Sukbae (이석배) and Kim Ji-Hoon (김지훈) began studying this material as a potential superconductor starting in 1999.[3]:1 In 2023, they published preprints claiming that it acts as a room-temperature superconductor[3]:8 at temperatures of up to 400 K (127 °C; 260 °F) at ambient pressure.[2][4][3]:1

Many different labs attempted to replicate the work, and were able to reach initial results within weeks, as the process of producing the material is relatively straightforward.[5] As of 16 August 2023, however, the consensus[1] is that it is an insulator in pure form, and not a superconductor at any temperature:[6][7][8] copper-deficient copper(I) sulfide[9] formed as an impurity in the proposed synthesis can produce resistance drops, lambda transition in heat capacity, and magnetic response in small samples, which mimic transitions

Un cas de buzz médiatique autour de la supra

fin juillet : les amateurs entrent en scène

Andrew McCalip

Un cas de buzz médiatique autour de la supra

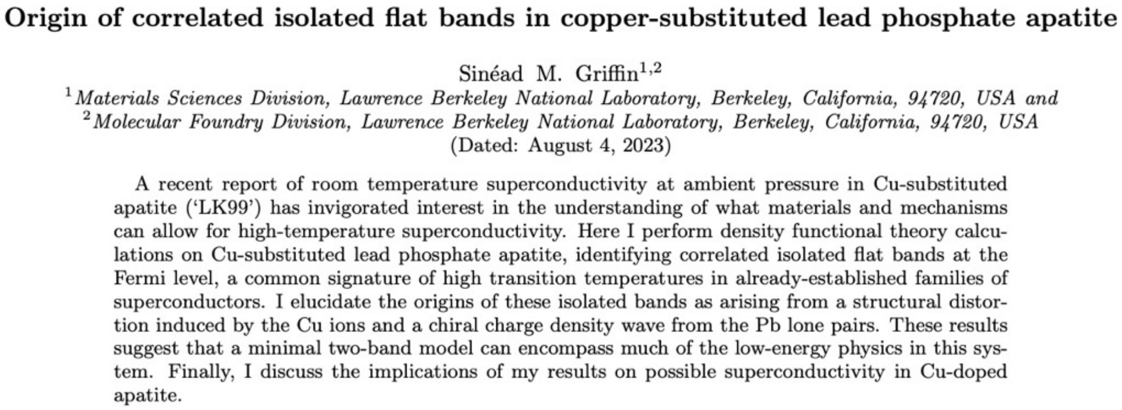
31 juillet : au tour des théoriciens

Sinéad Griffin @sineatrix · 1 août

arxiv.org/abs/2307.16892 #lk99

Un cas de buzz médiatique autour de la supra

31 juillet : au tour des théoriciens



Origin of correlated isolated flat bands in copper-substituted lead phosphate apatite

Sinéad M. Griffin[1,2]
[1]*Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California, 94720, USA and*
[2]*Molecular Foundry Division, Lawrence Berkeley National Laboratory, Berkeley, California, 94720, USA*
(Dated: August 4, 2023)

A recent report of room temperature superconductivity at ambient pressure in Cu-substituted apatite (‘LK99’) has invigorated interest in the understanding of what materials and mechanisms can allow for high-temperature superconductivity. Here I perform density functional theory calculations on Cu-substituted lead phosphate apatite, identifying correlated isolated flat bands at the Fermi level, a common signature of high transition temperatures in already-established families of superconductors. I elucidate the origins of these isolated bands as arising from a structural distortion induced by the Cu ions and a chiral charge density wave from the Pb lone pairs. These results suggest that a minimal two-band model can encompass much of the low-energy physics in this system. Finally, I discuss the implications of my results on possible superconductivity in Cu-doped apatite.

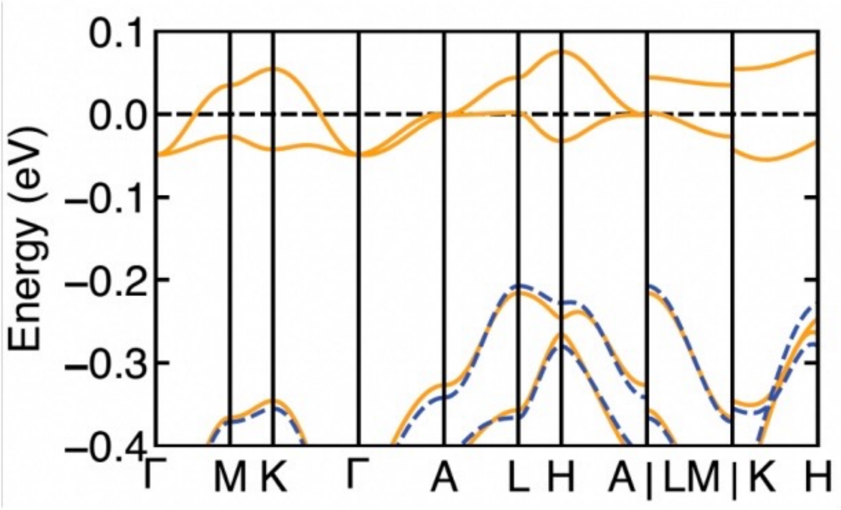
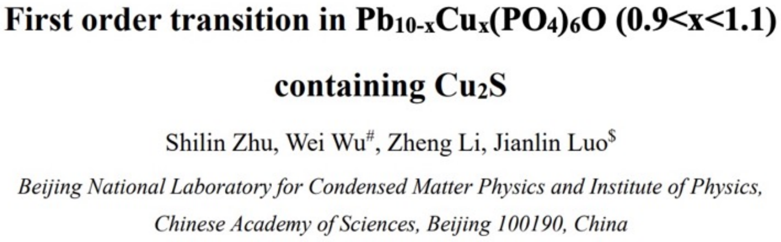


FIG. 4. Calculated spin-polarized electronic band structure in smaller energy range around the Fermi level showing the isolated two-band Cu-d manifold. The Fermi level is set to 0 eV and is marked by the dashed line.

Un cas de buzz médiatique autour de la supra

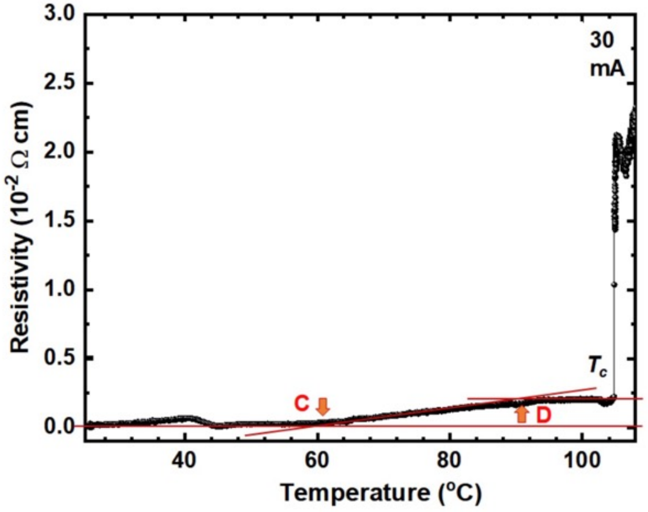
6 aout : les premiers résultats expérimentaux des « pros »



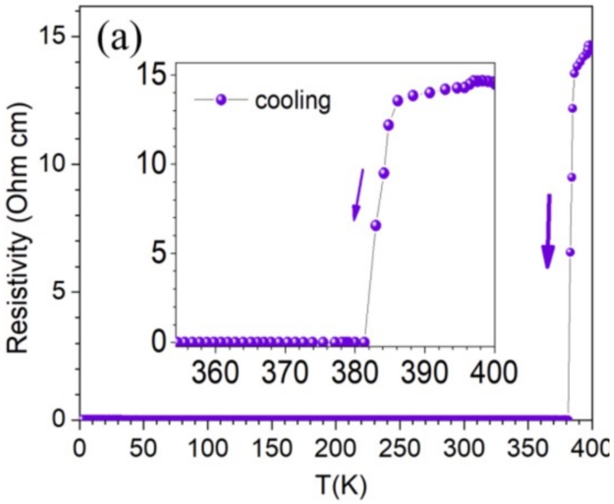
First order transition in $Pb_{10-x}Cu_x(PO_4)_6O$ (0.9<x<1.1) containing Cu_2S

Shilin Zhu, Wei Wu[#], Zheng Li, Jianlin Luo[$]

Beijing National Laboratory for Condensed Matter Physics and Institute of Physics,
Chinese Academy of Sciences, Beijing 100190, China



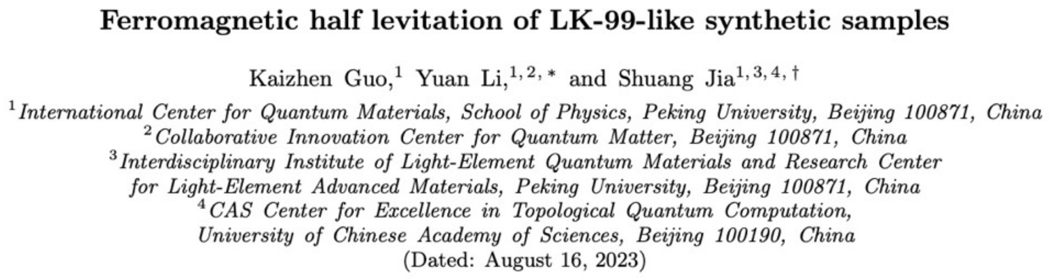
les coréens



Cu_2S

Un cas de buzz médiatique autour de la supra

6 aout : les premiers résultats expérimentaux des « pros »



Ferromagnetic half levitation of LK-99-like synthetic samples

Kaizhen Guo,[1] Yuan Li,[1,2,*] and Shuang Jia[1,3,4,†]
[1] *International Center for Quantum Materials, School of Physics, Peking University, Beijing 100871, China*
[2] *Collaborative Innovation Center for Quantum Matter, Beijing 100871, China*
[3] *Interdisciplinary Institute of Light-Element Quantum Materials and Research Center for Light-Element Advanced Materials, Peking University, Beijing 100871, China*
[4] *CAS Center for Excellence in Topological Quantum Computation, University of Chinese Academy of Sciences, Beijing 100190, China*
(Dated: August 16, 2023)

les coréens

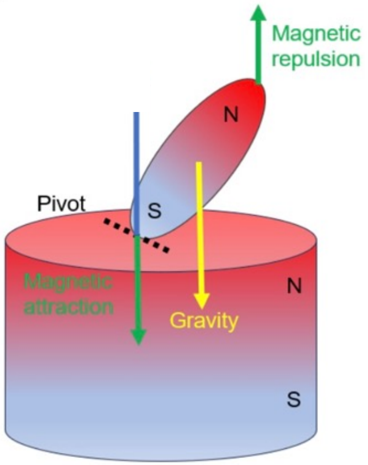


FIG. S2: Schematic diagram of force analysis of a magnetic small piece half-levitated on a magnet.

une plaque magnétique

Un cas de buzz médiatique autour de la supra

11 aout

Le beau cristal

Un cas de buzz médiatique autour de la supra

11 aout : les premiers résultats sur un bon cristal

Single crystal synthesis, structure, and magnetism of $Pb_{10-x}Cu_x(PO_4)_6O$

P. Puphal*,[1] M. Y. P. Akbar,[1,2] M. Hepting,[1] E. Goering,[1] M. Isobe,[1] A. A. Nugroho,[1,2] and B. Keimer[1]

[1] *Max Planck Institute for Solid State Research, Heisenbergstraße 1, D-70569 Stuttgart, Germany*

[2] *Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung, Jl. Ganesha 10, 40132 Bandung, Indonesia*

LK-99 est un isolant transparent…

Un cas de buzz médiatique autour de la supra

Les questions que ça pose

Pourquoi une telle hype ?

Le rôle des réseaux sociaux : négatif ou positif ?

L’image de la science : négatif ou positif ?

Le processus scientifique a-t-il été respecté ?

La médiatisation est-elle bonne pour la science ?

l'électricité

Qu'avez-vous retenu ?

l'électricité

Cachez vos notes, et tentez d’écrire en quelques mots...

1 ou 2
ordres de
grandeur

un truc que vous
avez retenu sur la
physique associée

un résultat
de recherche
récente