UNIVERSITÄT ROSTOCK

Mathematisch-Naturwissenschaftliche Fakultät

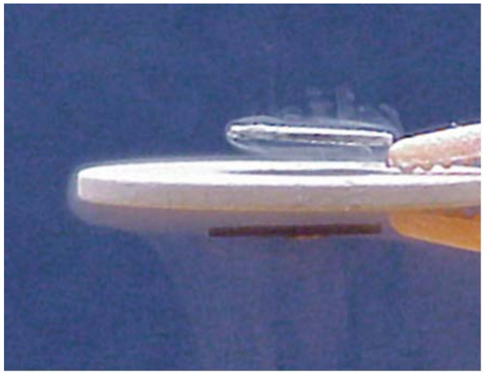
Institut für Chemie

Abteilung Anorganische Festkörperchemie

Prof. Dr. Martin Köckerling

Vorlesung

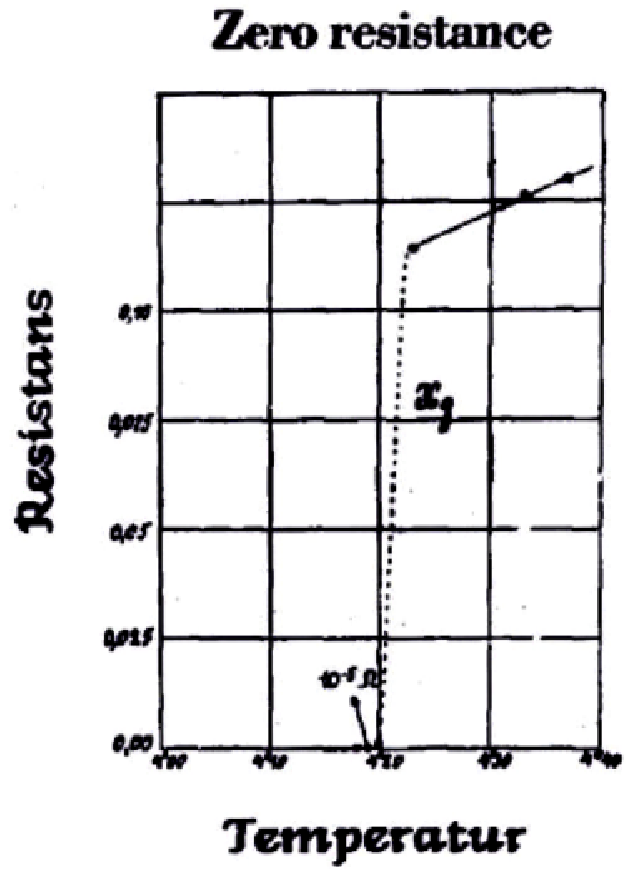
Anorganische Chemie VI – Materialdesign

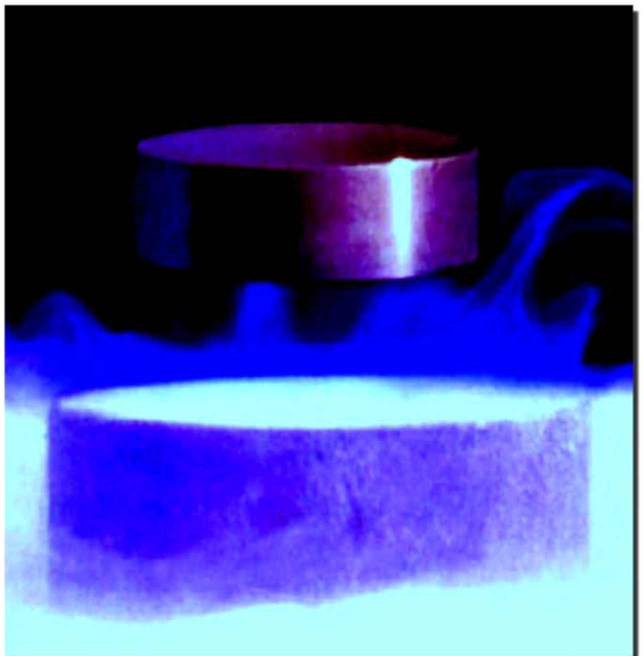


Heute: Supraleitung

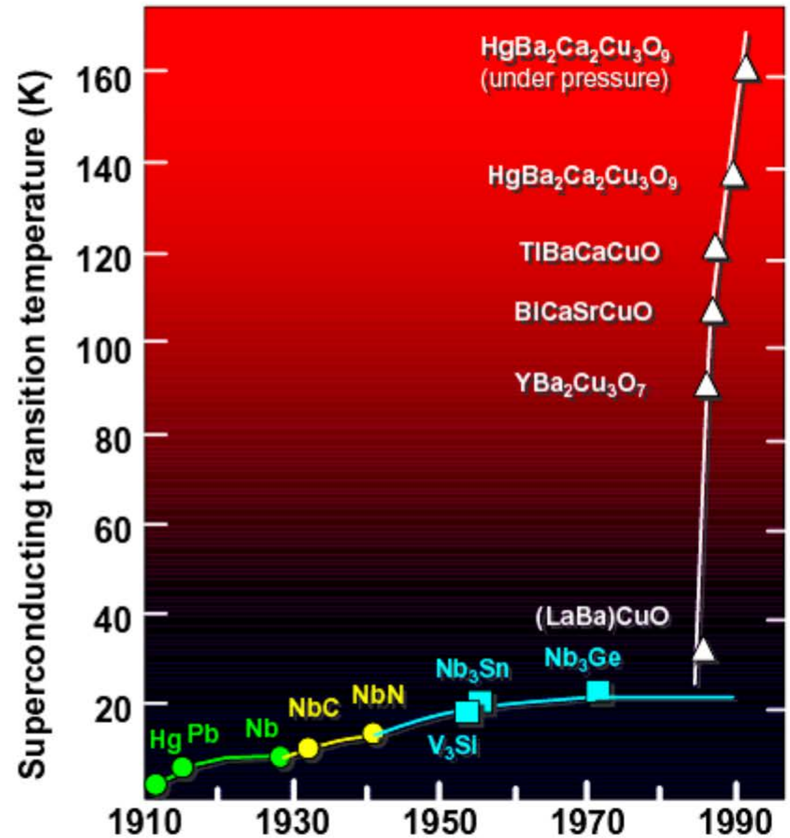
Magnet über supraleitendem Material

- Discovered by **Kamerlingh Onnes** in 1911 during first low temperature measurements to liquefy helium
- Whilst measuring the resistivity of “pure” Hg he noticed that the electrical resistance dropped to zero at 4.2K
- In 1912 he found that the resistive state is restored in a magnetic field or at high transport currents





“Superconductivity is perhaps the most remarkable physical property in the Universe” David Pines



Vielfältige technische Anwendungsmöglichkeiten, z.B.:

Materialien mit supraleitenden Eigenschaften

1. Elemente (Nb, 9.2 K).

2. Intermetallische Phasen (Nb_3Ge, 23 K)
   (UPd_2Al_3 , 2 K)

3. Chalcogenide ($LaMo_6Se_8$, 11 K)

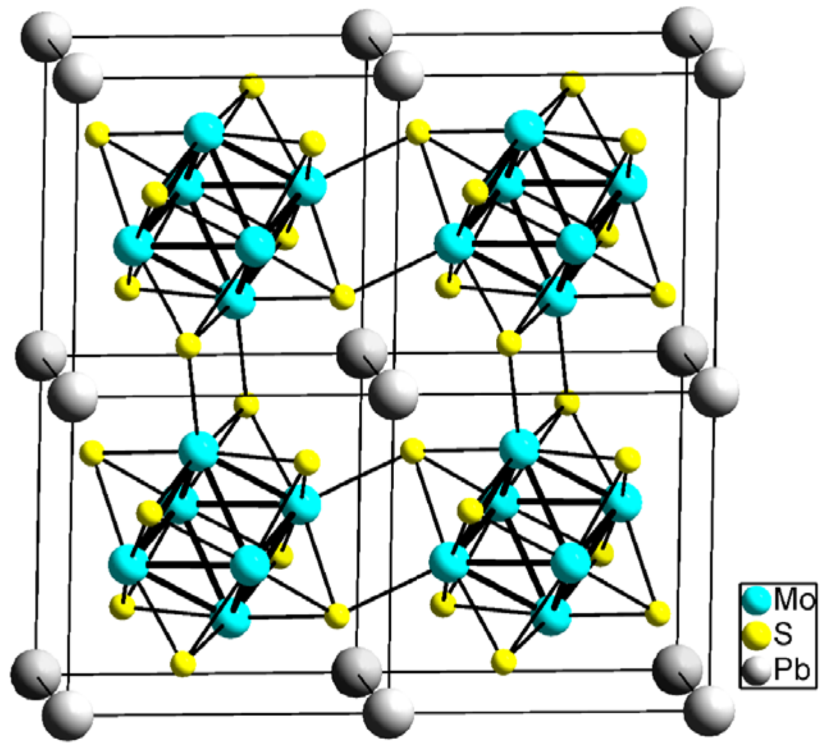
4. Boride ($ErRh_4B_4$, 8.8 K)
   (MgB_2, 40 K)

5. Oxide ($Tl_2Ba_2Ca_2Cu_3O_{10}$, 125 K)
   ($HgBa_2Ca_2Cu_3O_{8+\delta}$, 133 K $\xrightarrow{\text{HP}}$ 164 K

6. Organische Substanzen ($(Rb/Tl)_xC_{60}$, 45 K)
   (Rb_2CsC_{60}, 33 K)

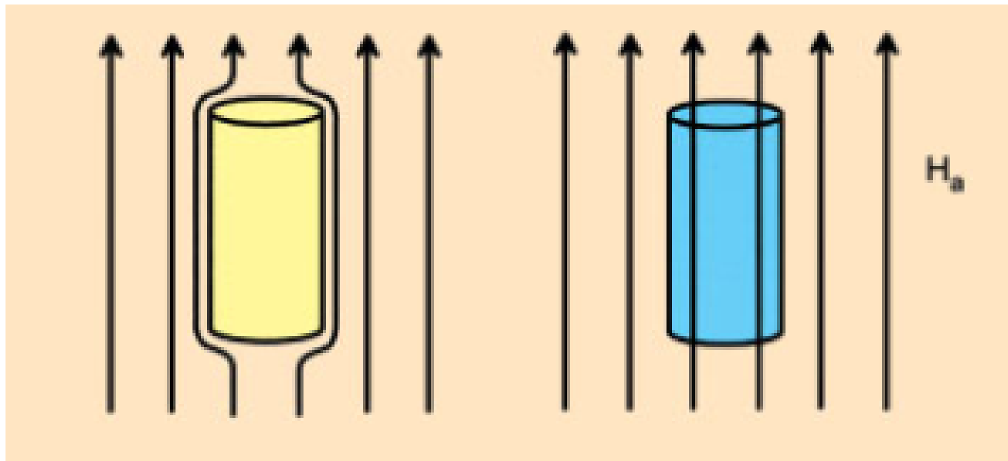
7. Oxopnictide

$PbMo_6S_8$



Etwas Theorie – einige Begriffe

Meißner-Ochsenfeld-Effekt: Verdrängung der Magnetfeldlinien aus dem Inneren eines Supraleiters



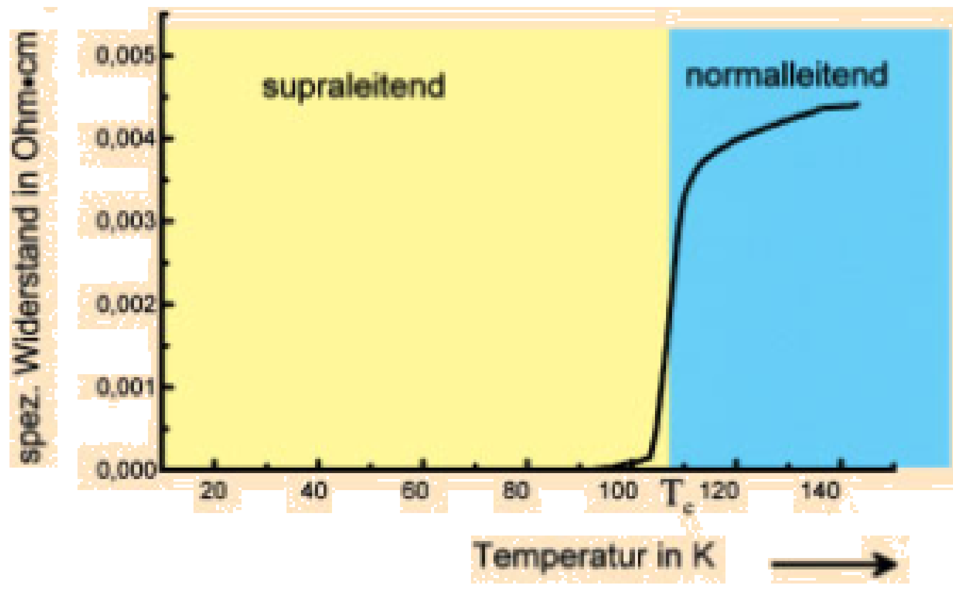
BCS-Theorie: Bardeen, Cooper, Schrieffer (Nobelpreis 1972),

Elektronen-Phononen-Kopplung:

Cooper-Paare

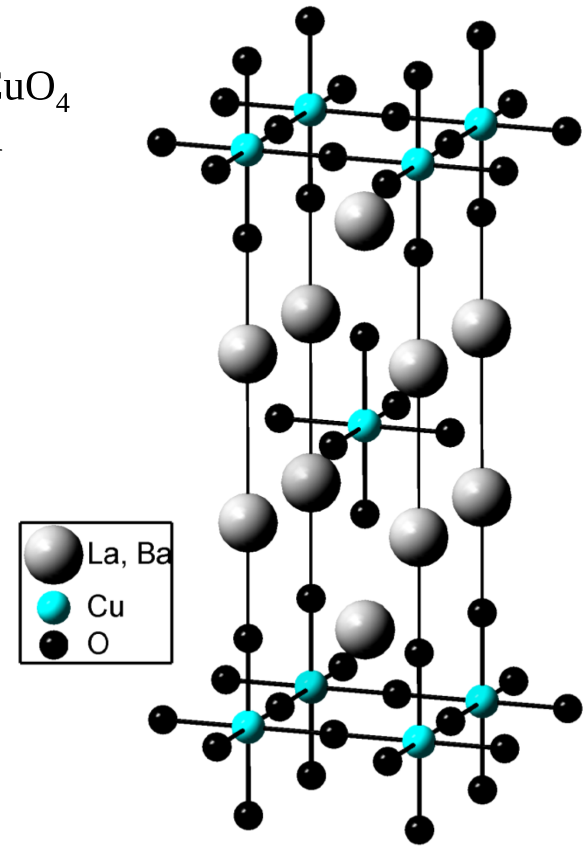
Kritische Magnetfeldstärke

Kritische Stromstärke

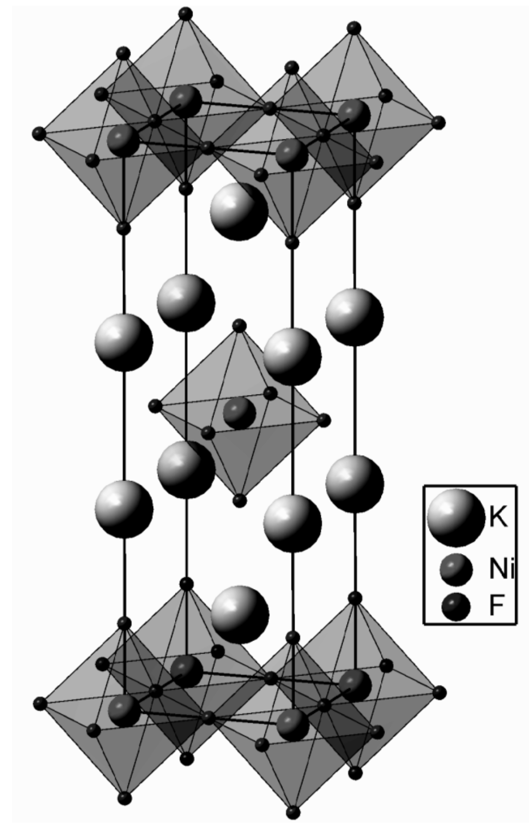


Hochtemperatur-Supraleiter: Bednorz/Müller (Nobelpreis 1987)

$La_{2-x}Ba_xCuO_4$
Tc = 35 K

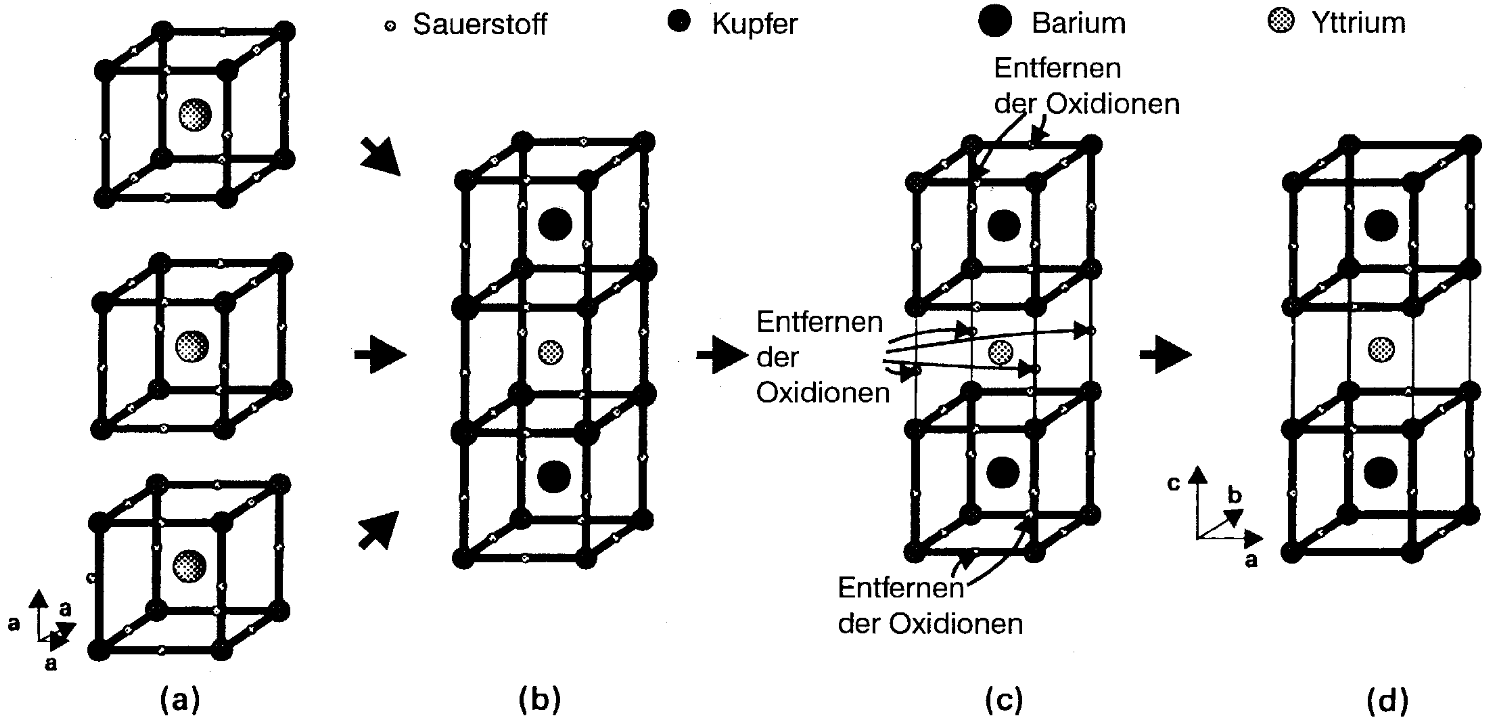


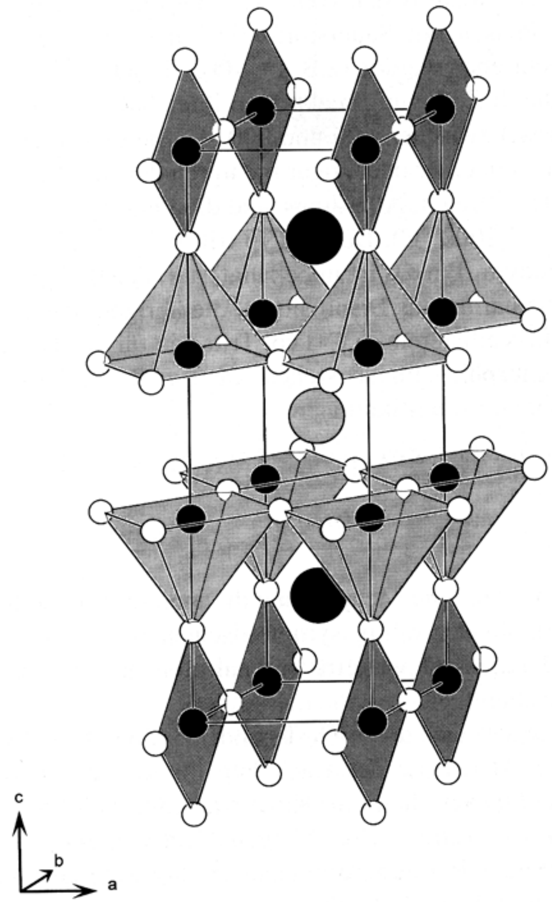
abgeleitet von K_2NiF_4:

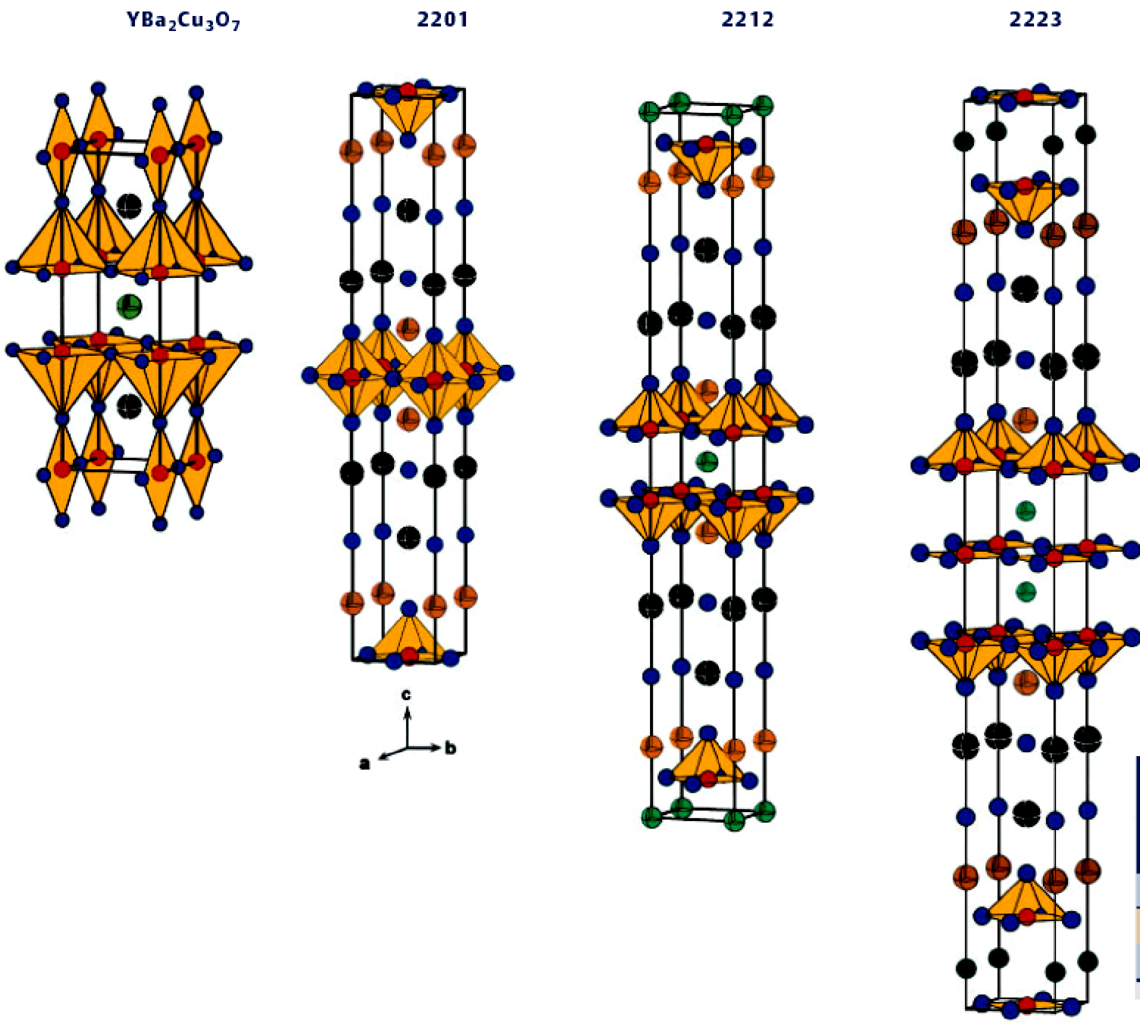


1-2-3-Supraleiter: $YBa_2Cu_3O_{7-x}$ Tc = 93 K, 0 < x < 1 (Sdp. N_2 77 K)

3 ABX_3 ==> $(A_3)(B_3)(X_9)$ ==> $(YBa_2)(Cu_3)(O_7\Diamond_2)$ (Perowskit)




c
b
a

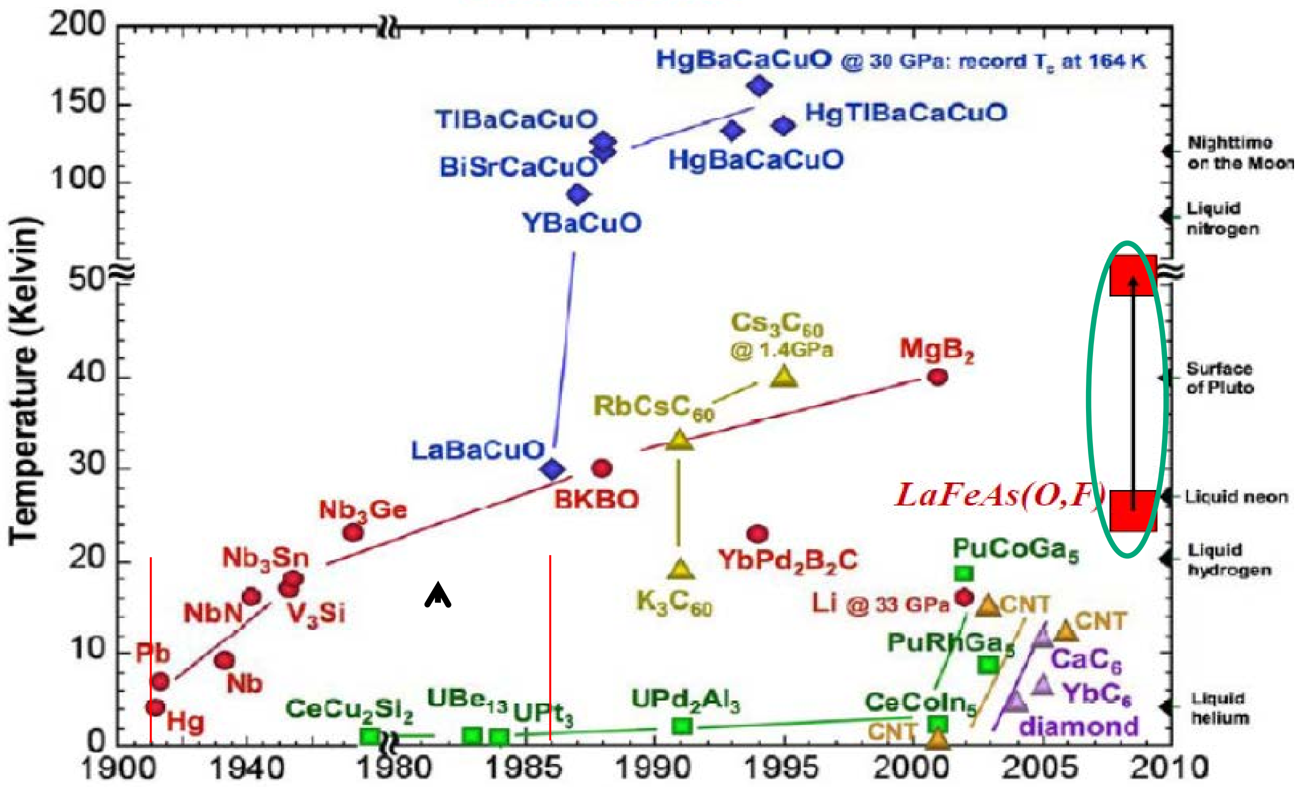


Idealisierte Elementarzellen von $Bi_2Sr_2Ca_0Cu_1O_6$ (2201), $Bi_2Sr_2Ca_1Cu_2O_8$ (2212), $Bi_2Sr_2Ca_2Cu_3O_{10}$ (2223) mit zwei Formeleinheiten (von links nach rechts). Cu-Atome sind rot, O-Atome blau, Sr-Atome braun, Bi-Atome schwarz und Ca-Atome sind grün gezeichnet.

Substanz	Anzahl benachbarter CuO_2-Schichten, n	Übergangstemperatur in K
$Bi_2Sr_2CuO_{6+\delta}$	1	10
$Bi_2Sr_2CaCu_2O_{8+\delta}$	2	ca. 80
$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+\delta}$	3	110

Supraleiter

Materials

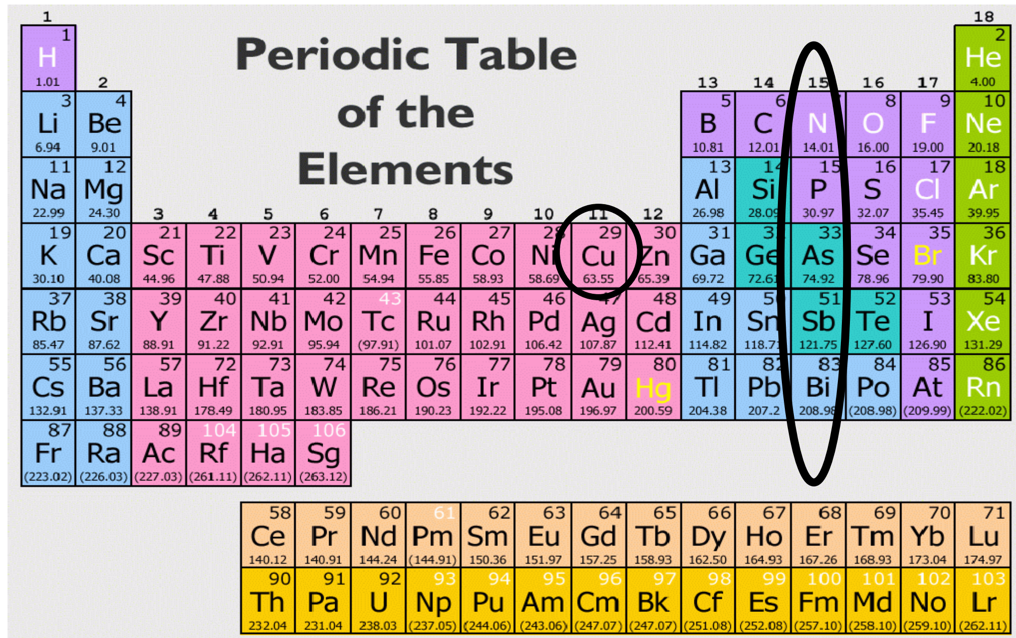


1911 **1986** Year

Supraleitfähigkeit in Oxopicniden

LnOFePn

Ln = Selten-Erd
Pn = Pnictogen
(5. HG)
N, P, As, Sb, Bi

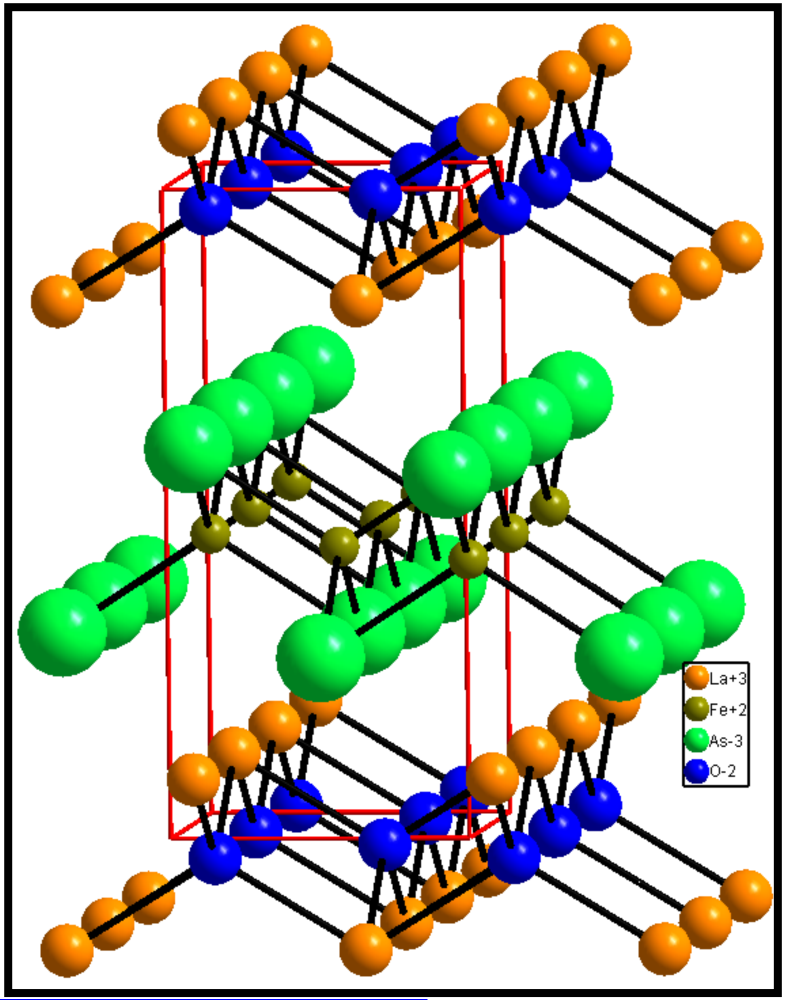


Ferromagnetisches Fe und Supraleitfähigkeit:
Überraschung!!!!

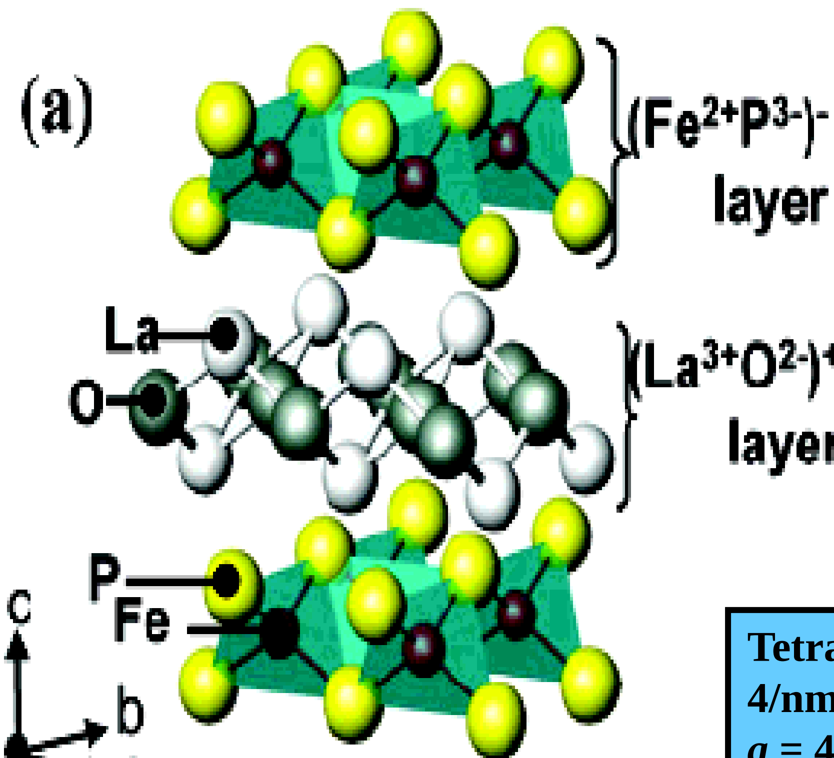
LaOFeP, $T_c \sim 4$ K ,
$LaO_{0.94}F_{0.06}FeP \sim 7$ K

LaONiP Tc= ~ 3K

LnOFeAs



LaOFeP (1995) Jeitschko, J Alloys and Compds.
LaOFeAs (2000) Zimmer, Jeitschko et. al J A C



Tetragonal; *P* 4/nmm
a = 4.0353(0) Å
c = 8.7409(1) Å

Anwendungen:

- Energietransport
- Energiespeicherung (SMES = supermagnetic energy storage)
- Magnetschwebebahnen (MAGLEV = magnetic levitation train)
- Hochenergiephysik
- NMR (Kernspintomographie)
- SQUID (= superconducting quantum interference device)

- Elektromagnete, z.B. in NMR-Geräten, Kernspintomografen, Teilchenbeschleunigern