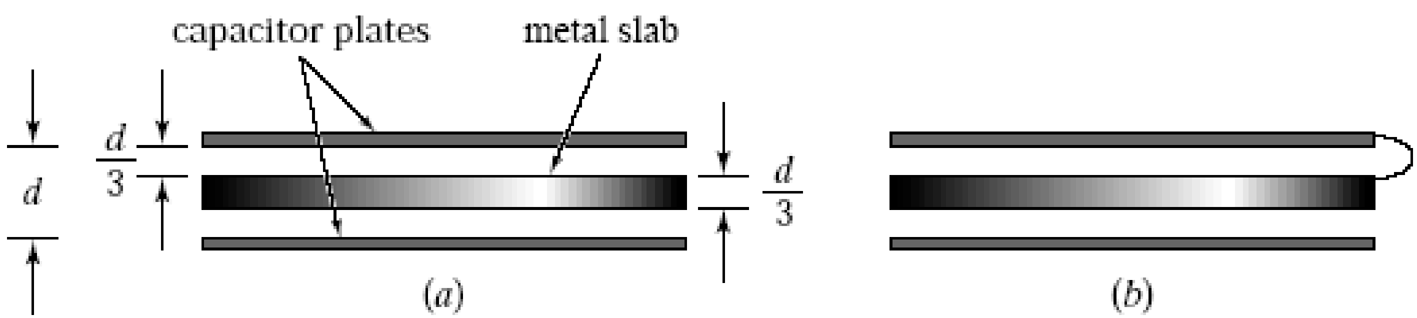
Table 30-2
Three electric vectors

Name	Symbol	Associated with	Boundary Condition
Electric field	**E**	All charges	Tangential component continuous
Electric displacement	**D**	Free charges only	Normal component continuous
Polarization (electric dipole moment per unit volume)	**P**	Polarization charges only	Vanishes in a vacuum

Defining equation for **E**	$\mathbf{F} = q\mathbf{E}$	Eq. 27-2
General relation among the three vectors	$\mathbf{D} = \epsilon_0\mathbf{E} + \mathbf{P}$	Eq. 30-23
Gauss's law when dielectric media are present	$\oint \mathbf{D} \cdot d\mathbf{S} = q$ (q = free charge only)	Eq. 30-26
Empirical relations for certain dielectric materials*	$\mathbf{D} = \kappa\epsilon_0\mathbf{E}$	Eq. 30-24
	$\mathbf{P} = (\kappa - 1)\epsilon_0\mathbf{E}$	Eq. 30-25

* Generally true, with κ independent of **E**, except for certain materials called *ferroelectrics;* see footnote on page 667.

Consider two capacitors, each having plate separation d. In each case, a slab of metal of thickness $d/3$ is inserted between the plates. In case (a), the slab is not connected to either plate. In case (b), it is connected to the upper plate. The capacitance is higher for

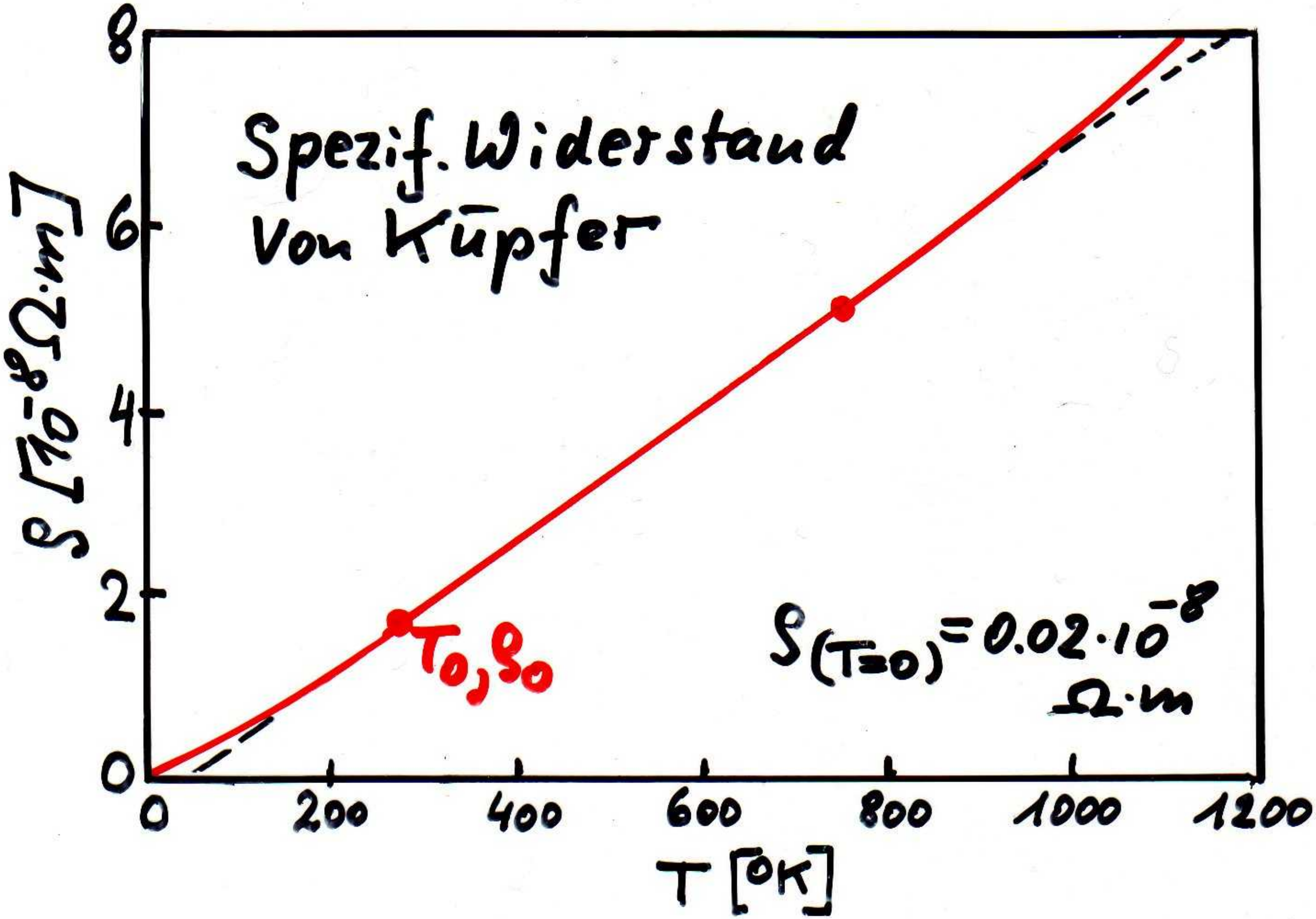


1. case (a).
2. case (b).
3. The two capacitances are equal.

Consider a capacitor made of two parallel metallic plates separated by a distance d. The top plate has a surface charge density $+\sigma$, the bottom plate $-\sigma$. A slab of metal of thickness $l < d$ is inserted between the plates, not connected to either one. Upon insertion of the metal slab, the potential difference between the plates

1. increases.
2. decreases.
3. remains the same.

2 -Asrbeit nötig, um Platte zu entfernen



Spezif. Widerstand
von Kupfer
ρ [10⁻⁸ Ω·m]
8
6
4
2
0
T₀, ρ₀
ρ(T=0) = 0.02·10⁻⁸ Ω·m
0
200
400
600
800
1000
1200
T [°K]

SPEZIFISCHER WIDERSTAND

	ρ (Ω cm)
ultrareines Wasser	10^7
1 x destilliertes Wasser	10^5
reines Trinkwasser	10^4
0.01 % HCL	10^3
30 % H_2SO_4	10^0

	α (10^{-3}/K)	**ρ (10^{-7} Ω cm)**
Silber	3.8	1.6
Kupfer	3.9	1.7
Aluminium	3.9	2.8
Wolfram	4.5	5.6
Nickel	6	6.8
Eisen	5	10
Stahl	3	18
Manganin	10^{-2}	44
Kohle	-0.5	3500

Widerstand von K bei tiefen Temperaturen

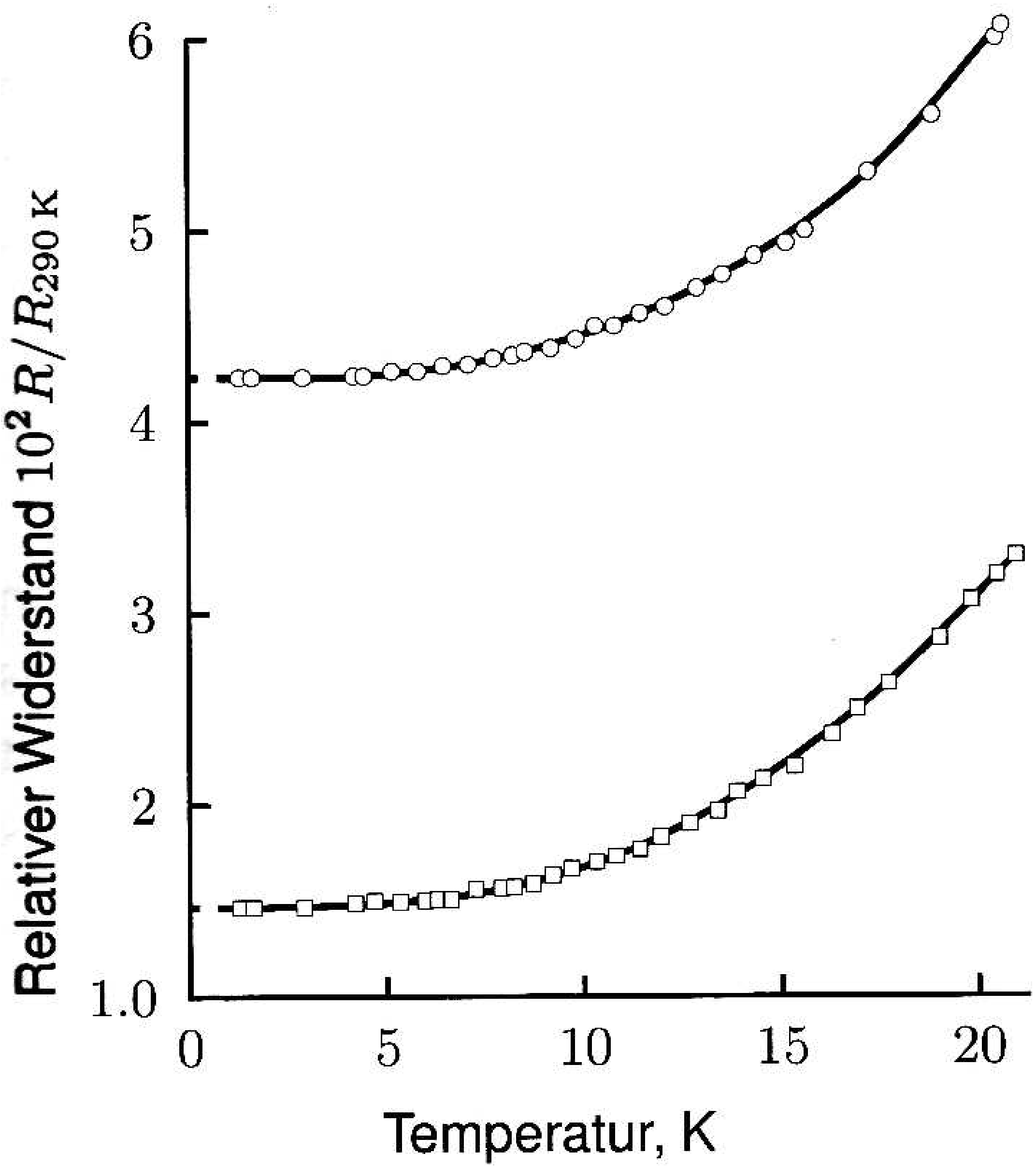
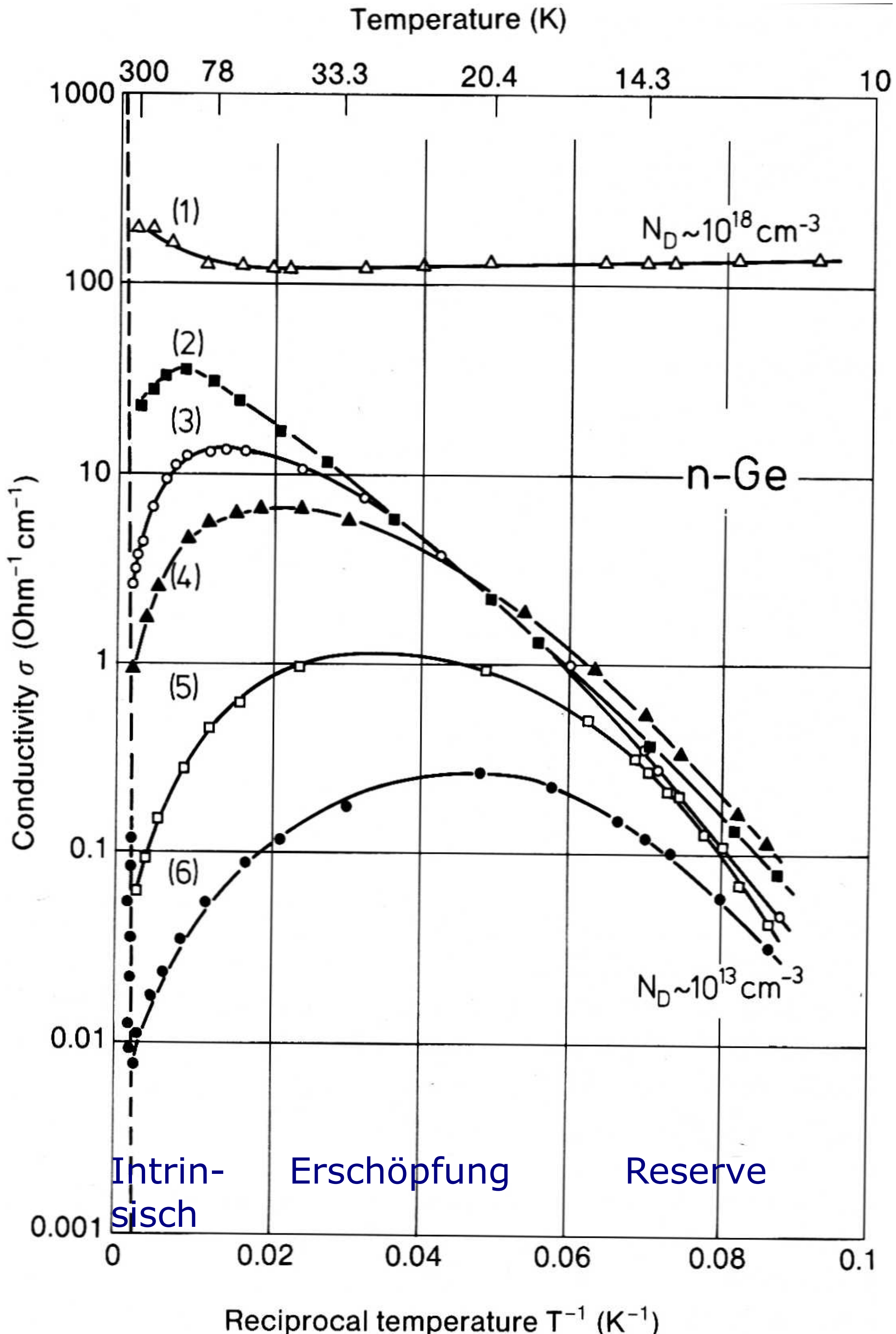


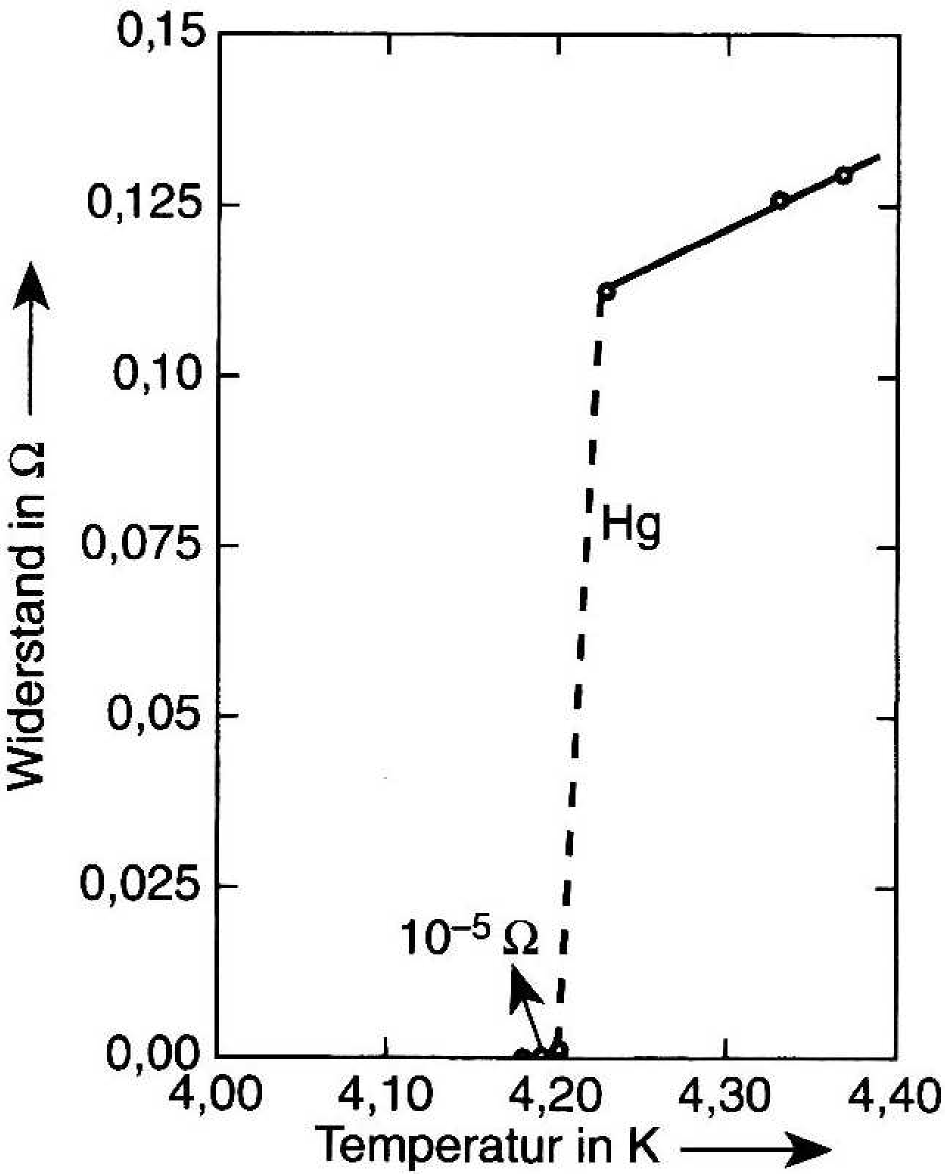
Bild 6.12: Widerstand von Kalium unterhalb 20 K, gemessen von D.K.C. MacDonald und K. Mendelsohn an zwei verschiedenen Proben. Die verschiedenen Achsenabschnitte bei 0 K sind durch unterschiedliche Konzentrationen von Verunreinigungen und statischen Gitterfehlern in den beiden Proben verursacht.

$\sigma = n e \mu$



Temperature (K)
300
78
33.3
20.4
14.3
10
1000
100
10
1
0.1
0.01
0.001
(1)
(2)
(3)
(4)
(5)
(6)
N_D ~10^18 cm^-3
n-Ge
N_D ~10^13 cm^-3
Conductivity σ (Ohm^-1 cm^-1)
0
0.02
0.04
0.06
0.08
0.1
Reciprocal temperature T^-1 (K^-1)
Intrin-
sisch
Erschöpfung
Reserve

Superconductivity



Normal metal (N):

$\rho = \rho_0 + a\,T^5$ at $T \ll \theta_D$

non-magnetic impurities & phonons

Superconductor:

$\rho = 0$ at $T < T_C$

Heike Kamerlingh Onnes

SPUNGTEMPERATUREN (K)

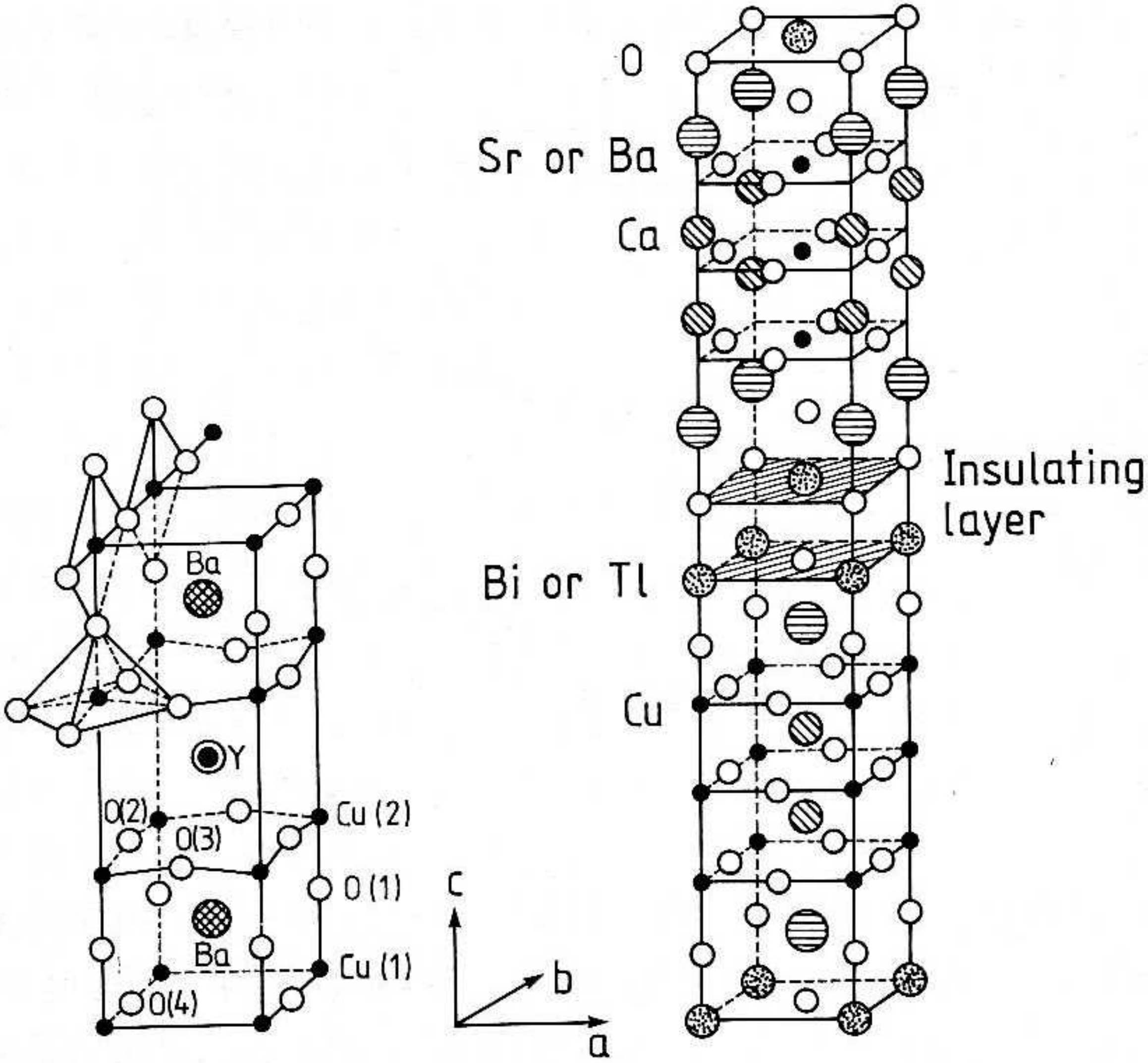
Hf	0.35	Hg	4.17
Ti	0.53	Ta	4.38
Zn	0.79	Pb	7.26
Al	1.14	Tc	11.2
In	3.37		

Cuprates

1983: copper-oxides
insulating ceramics
highest T_c known: 30 K
Nobel prize 1987

Courtesy of IBM Zurich Research Laboratory

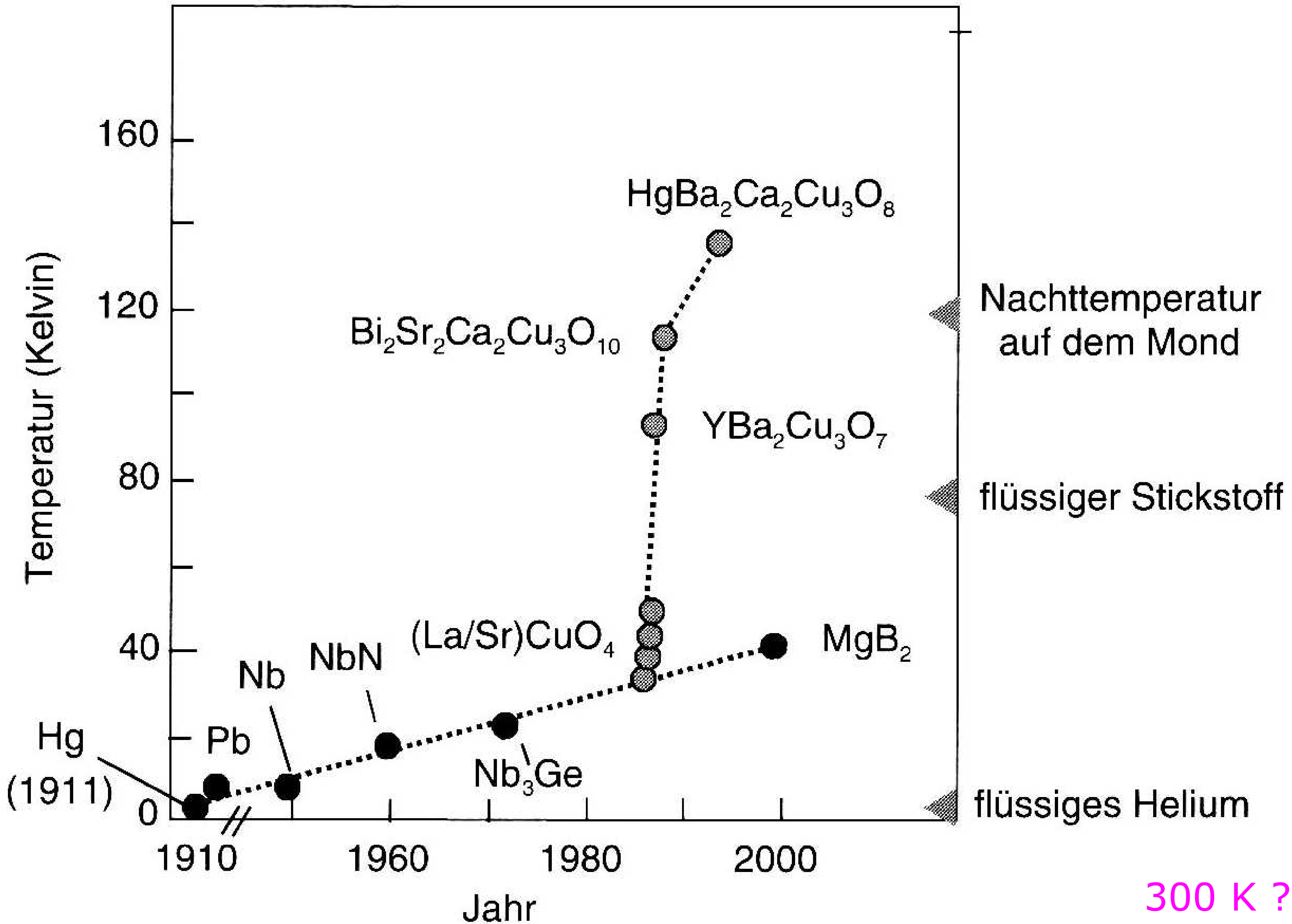
Alex Müller, Georg Bednorz



$YBa_2Cu_3O_7$

$Bi_2Sr_2Ca_2Cu_3O_{10}$ or $Tl_2Ba_2Ca_2Cu_3O_{10}$

$T_c(t)$



Temperatur (Kelvin)
160
120
80
40
0
Jahr
1910
1960
1980
2000
Hg
(1911)
Pb
Nb
NbN
Nb_3Ge
$(La/Sr)CuO_4$
$YBa_2Cu_3O_7$
$Bi_2Sr_2Ca_2Cu_3O_{10}$
$HgBa_2Ca_2Cu_3O_8$
MgB_2
Nachttemperatur auf dem Mond
flüssiger Stickstoff
flüssiges Helium

300 K ?