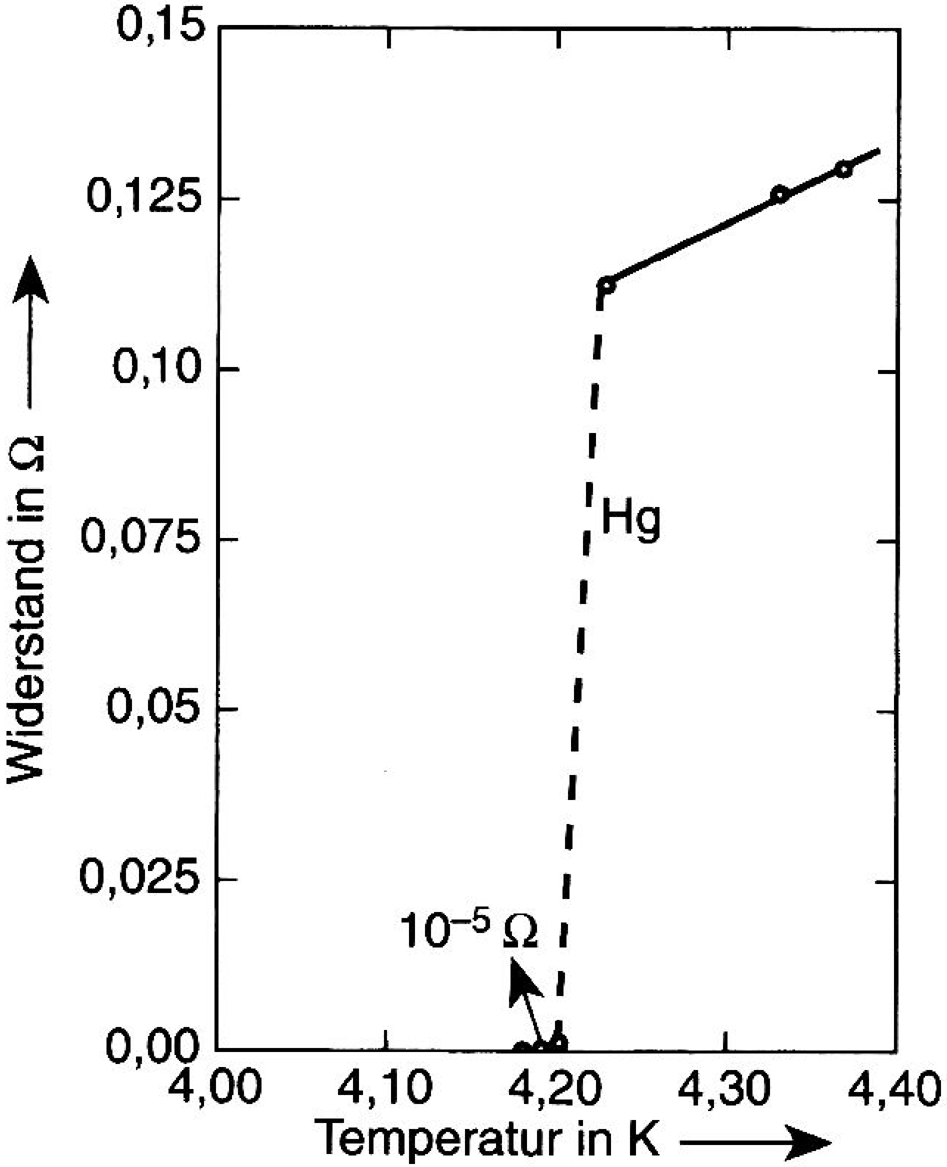
Superconductivity



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

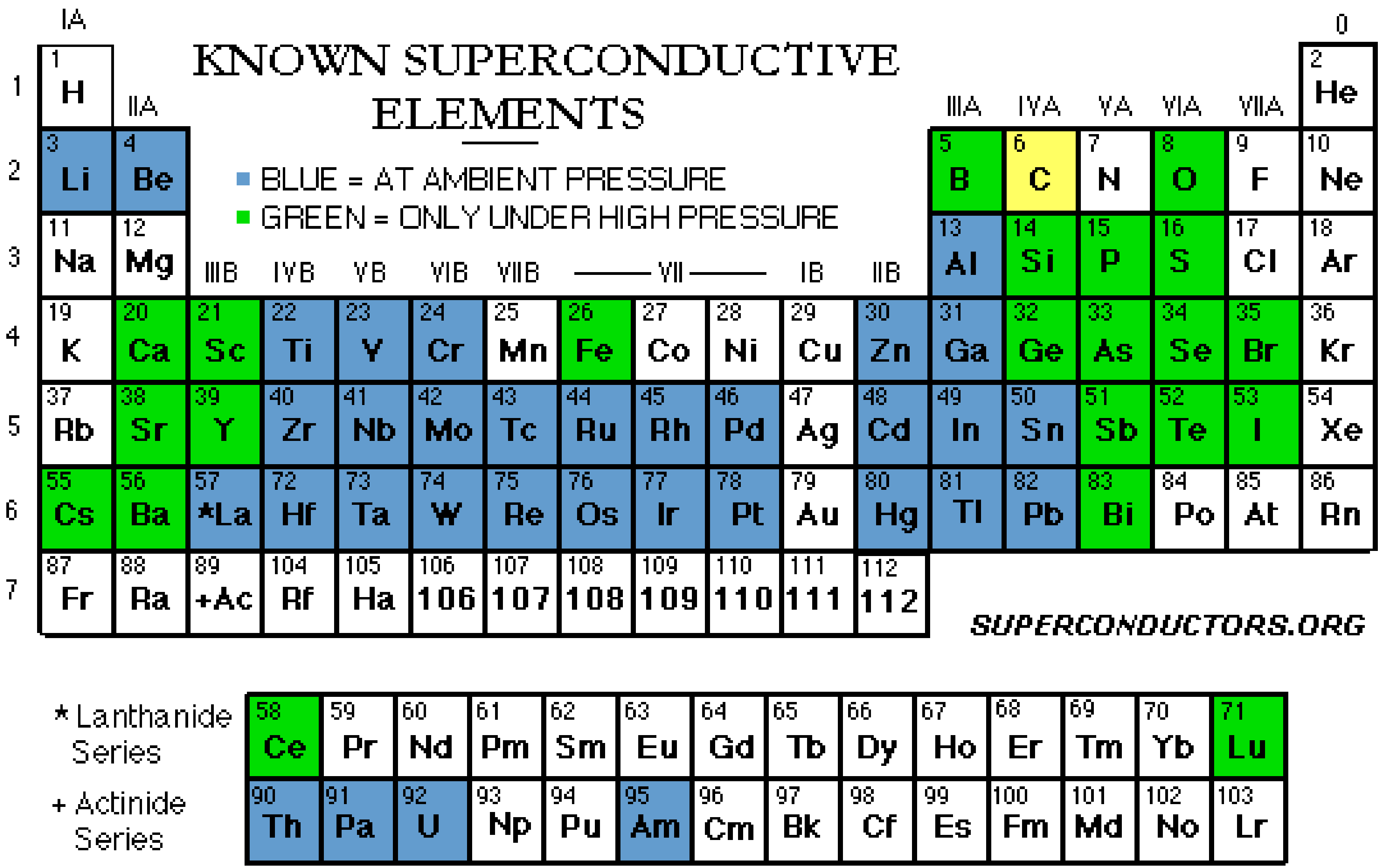
naheliegende Anwendungen

verlustfreier Energietransport

Magnetfelderzeugung (NMR, Transrapid)

weniger naheliegend

Quantenbauelemente (SQUID superconducting quantum interference device, RSFQ rapid single flux quantum)

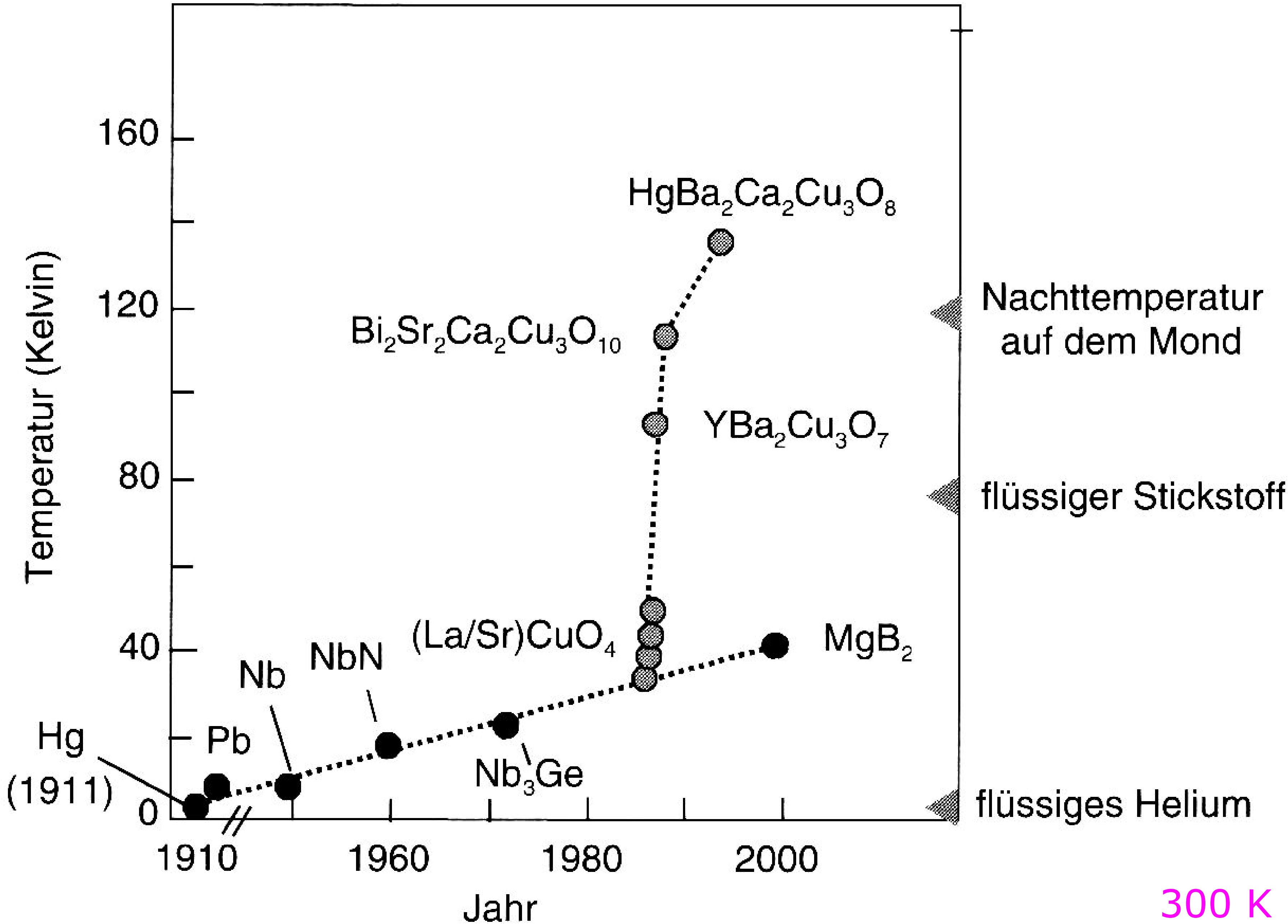


Most metals are superconductors

Some Type 1 Superconductors

Lead (Pb)	7.196 K
Lanthanum (La)	4.88 K
Tantalum (Ta)	4.47 K
Mercury (Hg)	4.15 K
Tin (Sn)	3.72 K
Indium (In)	3.41 K
Thallium (Tl)	2.38 K
Aluminum (Al)	1.175 K
Gallium (Ga)	1.083 K
Molybdenum (Mo)	0.915 K
Zinc (Zn)	0.85 K
Osmium (Os)	0.66 K
Cadmium (Cd)	0.517 K
Ruthenium (Ru)	0.49 K
Titanium (Ti)	0.40 K
Uranium (U)	0.20 K
Hafnium (Hf)	0.128 K
Iridium (Ir)	0.1125 K
Beryllium (Be)	0.023 K
Tungsten (W)	0.0154 K
Lithium (Li)	0.0004 K
Rhodium (Rh)	0.000325 K

$T_C(t)$



Temperatur (Kelvin)
160
120
80
40
0
HgBa2Ca2Cu3O8
Bi2Sr2Ca2Cu3O10
YBa2Cu3O7
(La/Sr)CuO4
MgB2
Nb3Ge
NbN
Nb
Pb
Hg
(1911)
Nachttemperatur auf dem Mond
flüssiger Stickstoff
flüssiges Helium
1910
1960
1980
2000
Jahr

300 K ?

Persistent current

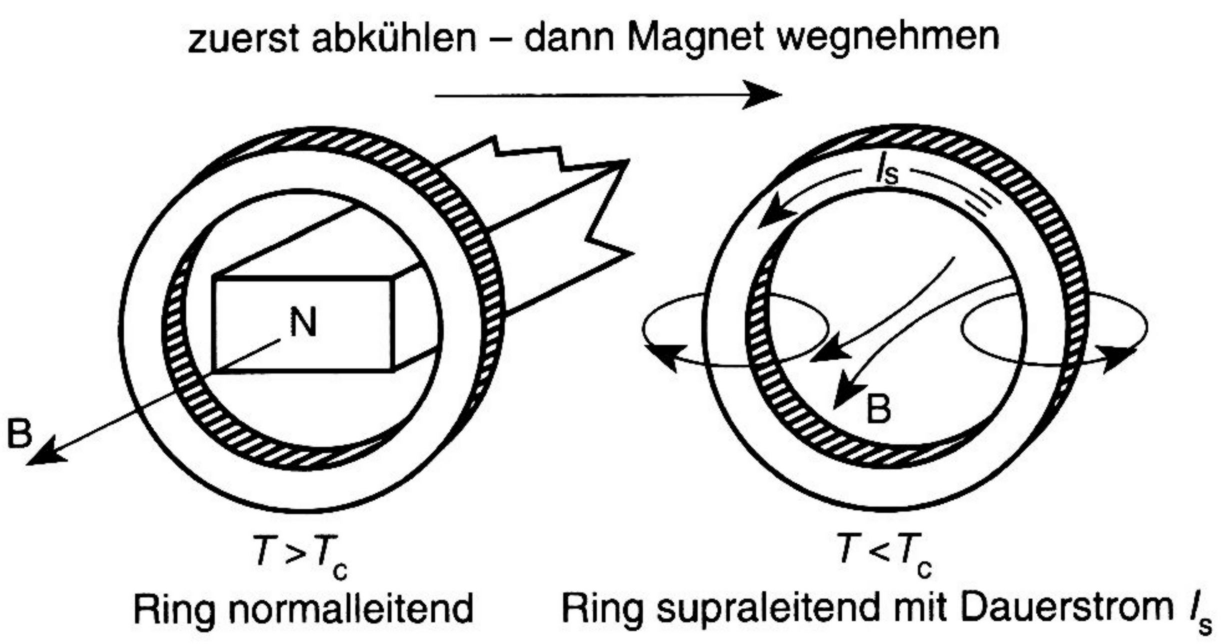
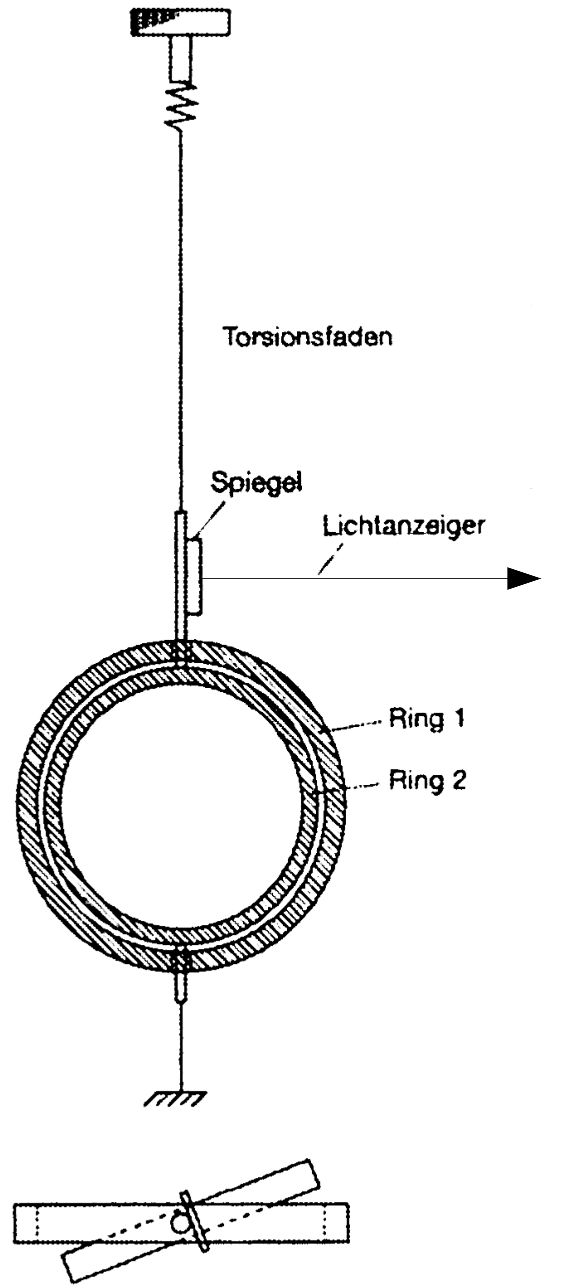


Abb. 1.1 Erzeugung eines Dauerstroms

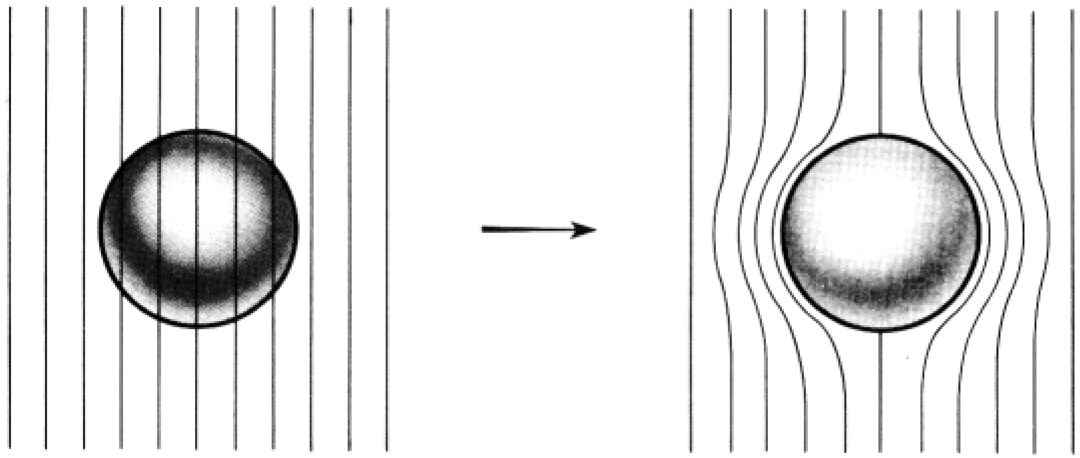


No decay detected over 2.5 years

No dissipation

Minimum estimated decay time > age of universe

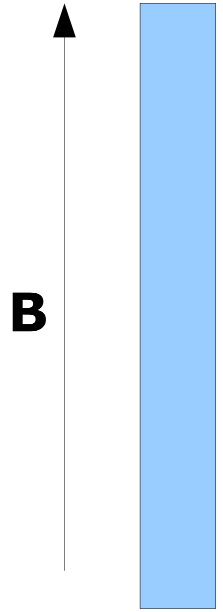
Meißner-Ochsenfeld-Effect (1933)



B field does not penetrate

= superconductors display

perfect diamagnetism



$\mathbf{B}_{in} = 0$

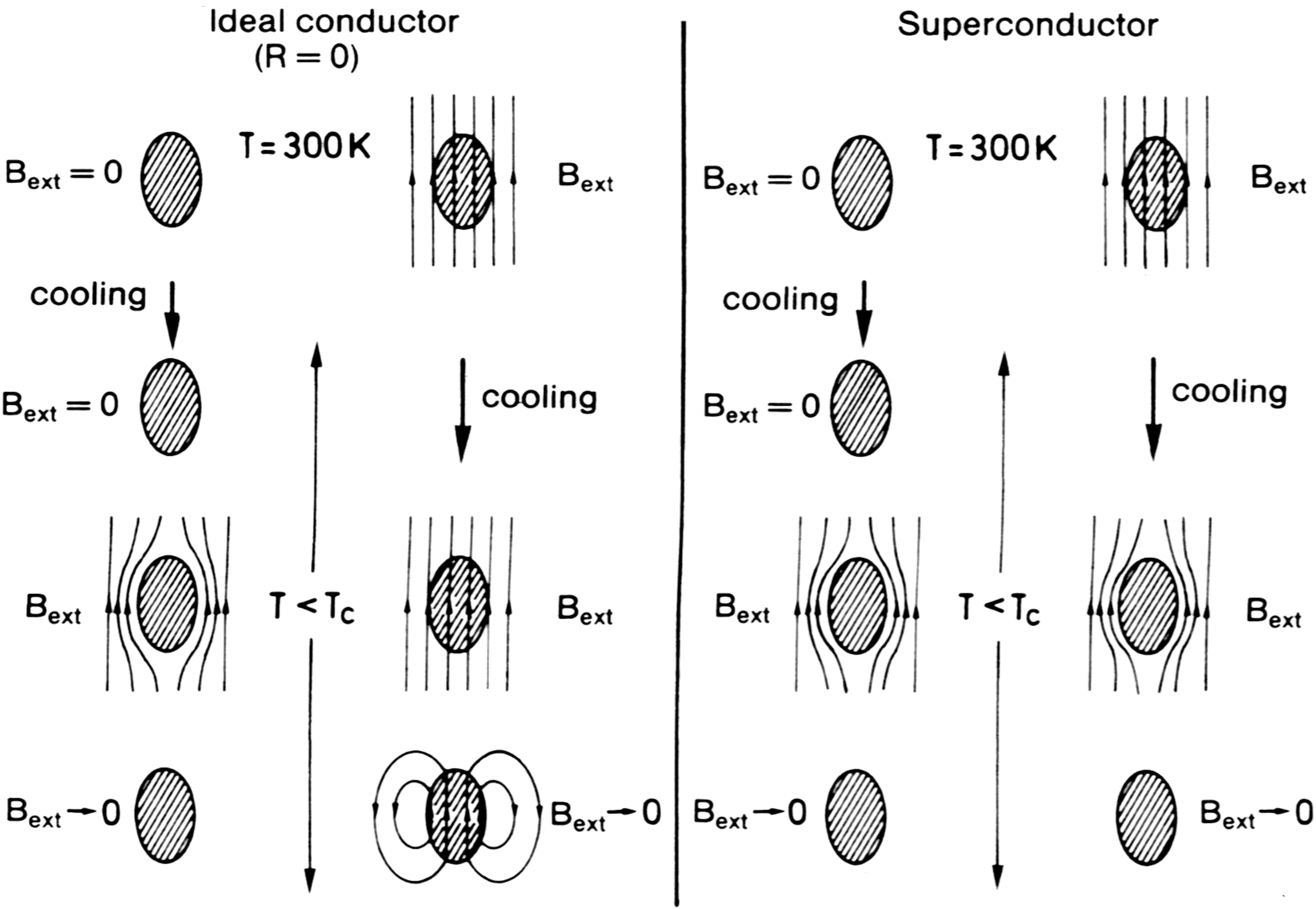
$\rightarrow \mu_0 \mathbf{M} + \mathbf{B} = 0$

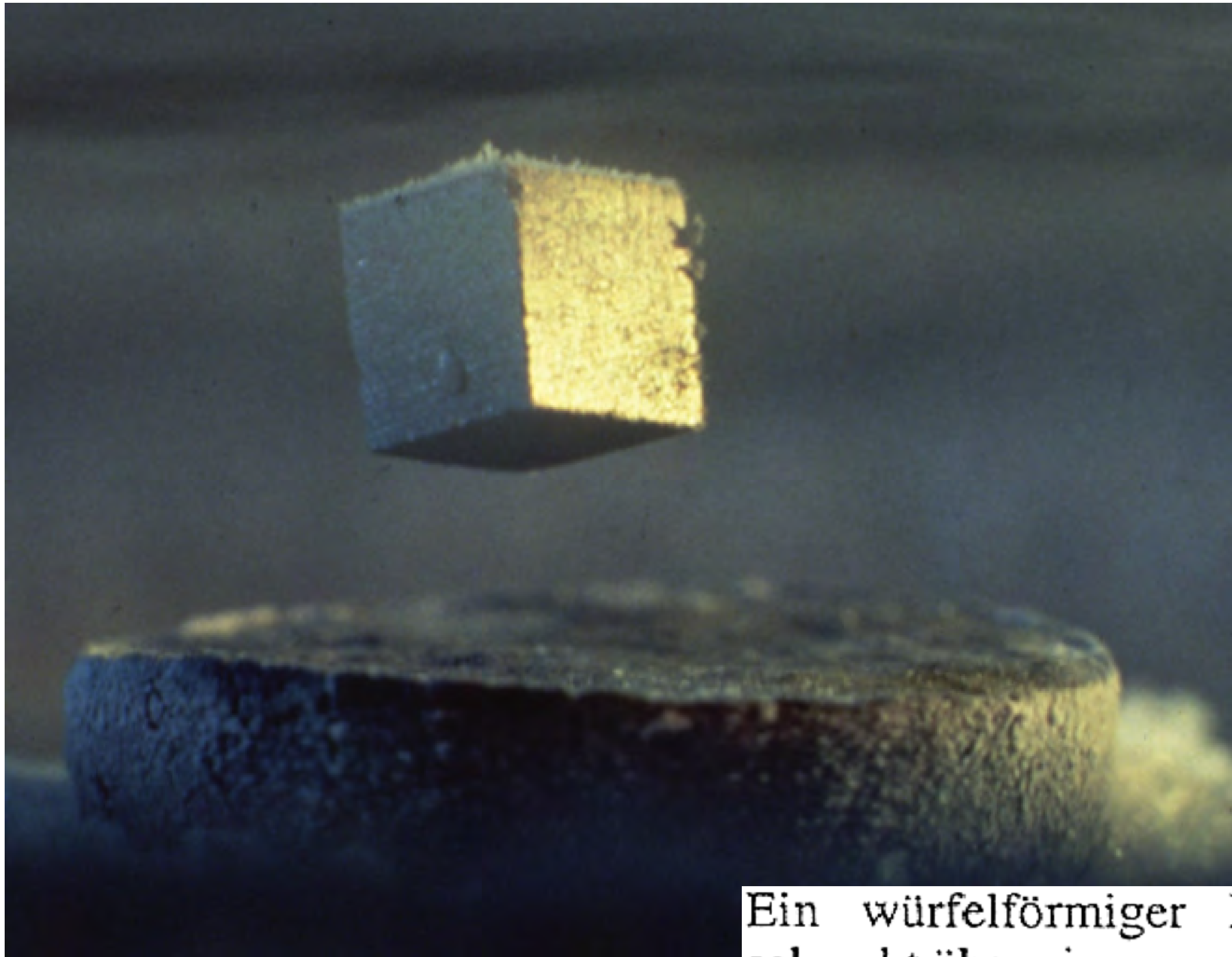
$\rightarrow \mathbf{M} = -\mathbf{B} / \mu_0$

$\rightarrow \chi = -1$

Walter Meißner

Perfekter Leiter vs. Supraleiter





Ein würfelförmiger Permanentmagnet schwebt über einer supraleitenden Scheibe aus dem Hochtemperatur-Supraleiter $YBa_2Cu_3O_7$. Das Schweben ist eine Folge des Meißner-Ochsenfeld-Effekts: Ein Supraleiter verhält sich wie ein idealer Diamagnet und stößt den Permanentmagneten ab. (© 1988 Richard Megna, Fundamental Photographs)