SUPERCONDUCTIVITY WS 15-16

Monday 10:00-11:30

SR Exp. physics II

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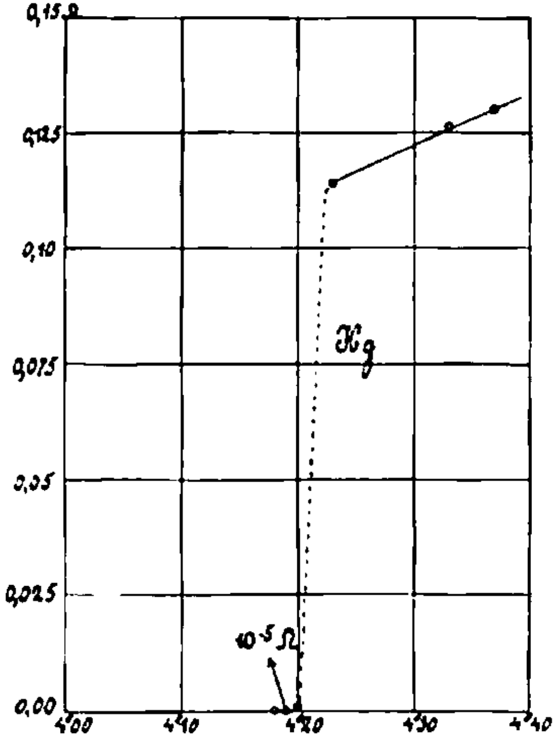
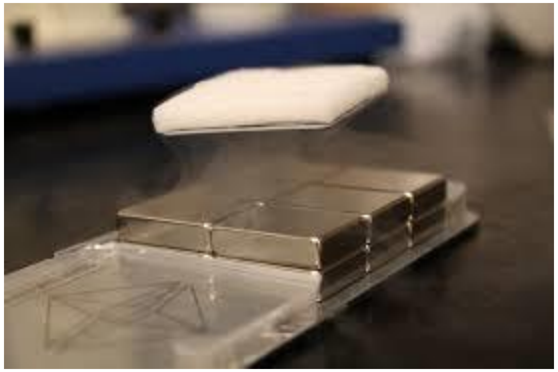
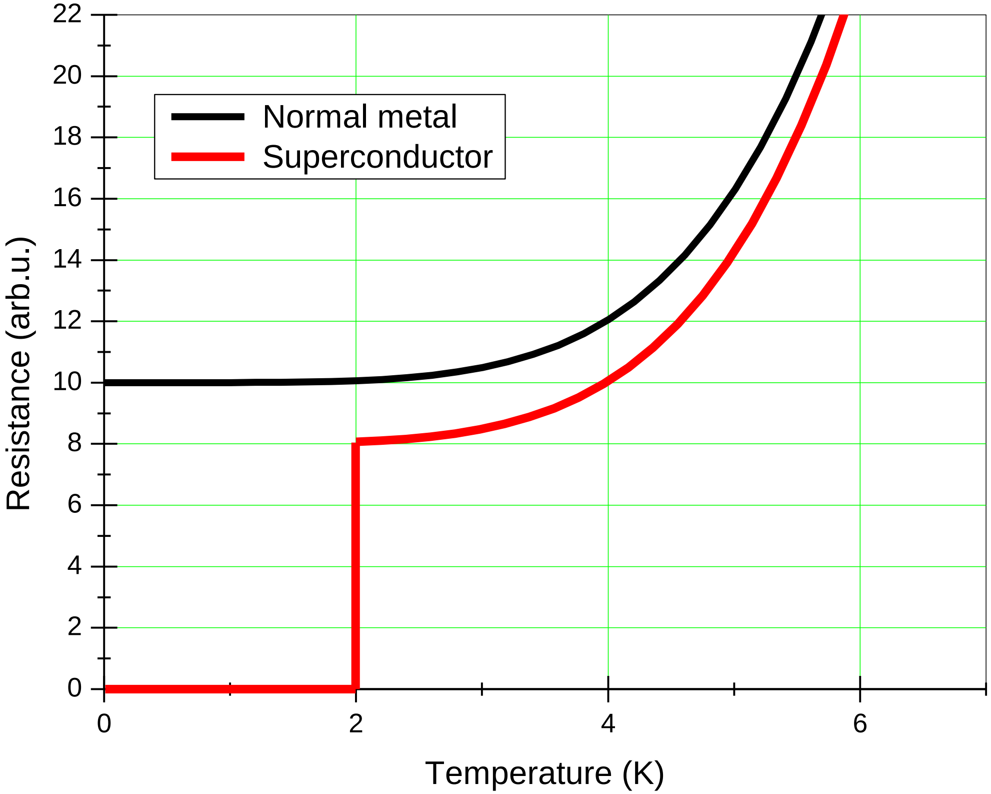
www.loosdrecht.net

Superconductivity
Basic properties





Perfect conductor



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

J.G. Bednorz and K.A. Müller

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

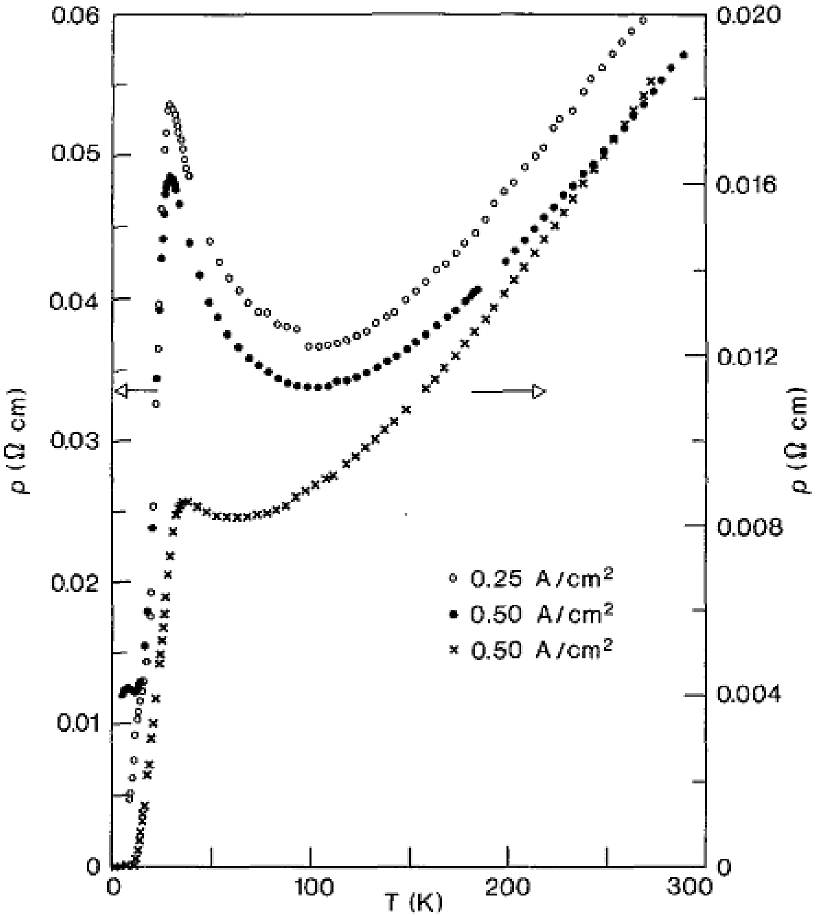


Fig. 1. Temperature dependence of resistivity in $Ba_xLa_{5-x}Cu_5O_{5(3-y)}$ for samples with $x(Ba)=1$ (upper curves, left scale) and $x(Ba)=0.75$ (lower curve, right scale). The first two cases also show the influence of current density

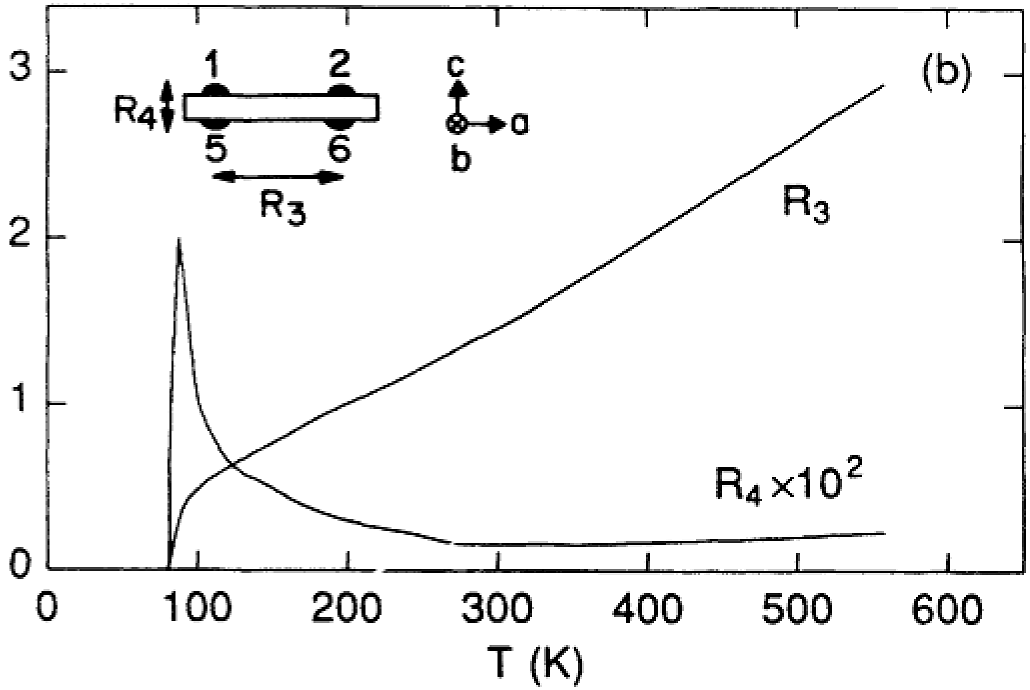
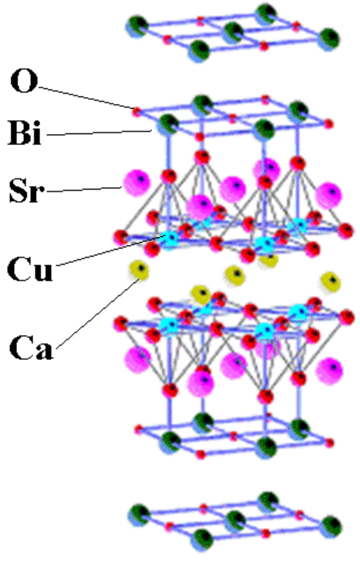


FIG. 1. (a) Temperature dependence of the resistances measured along the *a* and *b* axes of a BSCO single crystal. Inset: Schematic of the contact configuration. Onset of superconductivity occurs at $T = 90$ K and zero resistance is reached at $T_c = 81$ K. (b) Temperature dependence of the resistances measured along the *a* and *c* axes. The lines are drawn through closely spaced data points.



a Bi2212

VOLUME 60, NUMBER 21 PHYSICAL REVIEW LETTERS 23 MAY 1988

Temperature Dependence of the Resistivity Tensor in Superconducting $Bi_2Sr_{2.2}Ca_{0.8}Cu_2O_8$ Crystals

S. Martin, A. T. Fiory, R. M. Fleming, L. F. Schneemeyer, and J. V. Waszczak
AT&T Bell Laboratories, Murray Hill, New Jersey 07974

(Received 21 March 1988)

$BaLa_4Cu_5O_{13}$

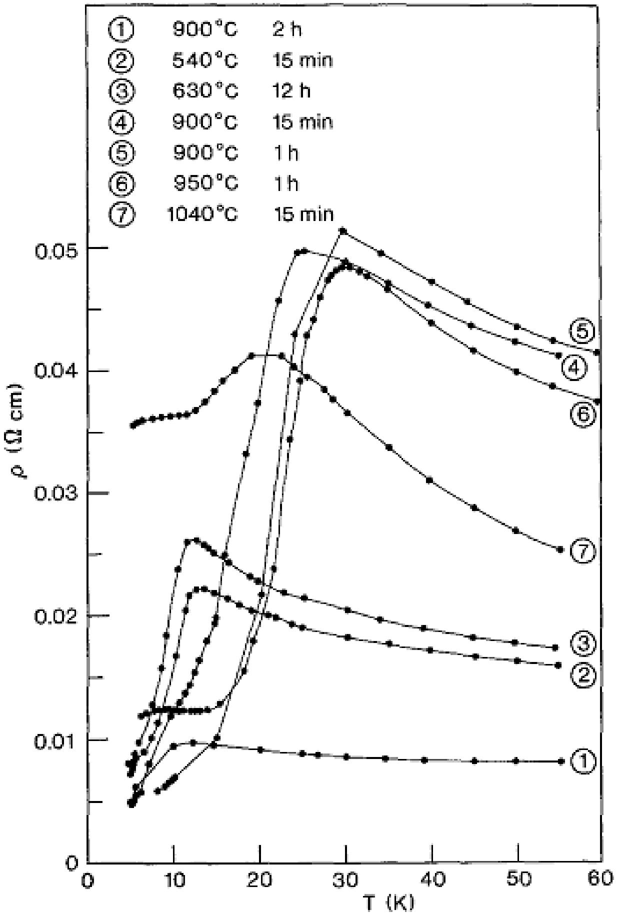


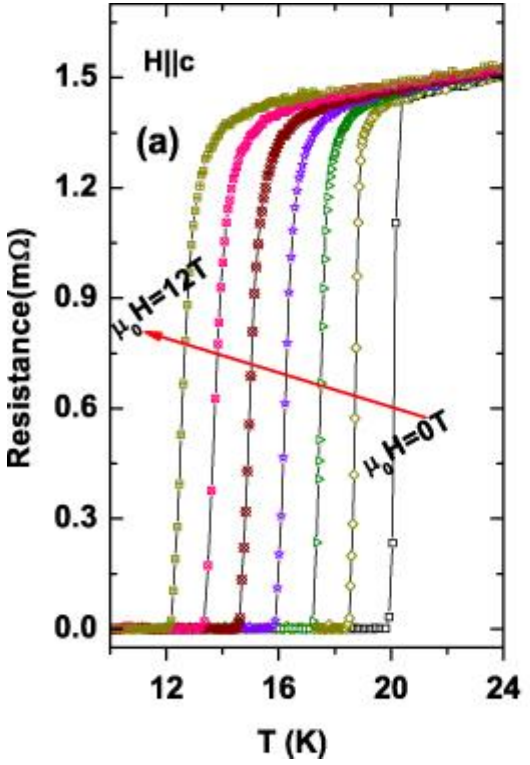
Fig. 2. Low-temperature resistivity of samples with x(Ba) = 1.0, annealed at O_2 partial pressure of 0.2 bar (curve ①) and 0.2×10^{-4} bar (curves ② to ⑦)

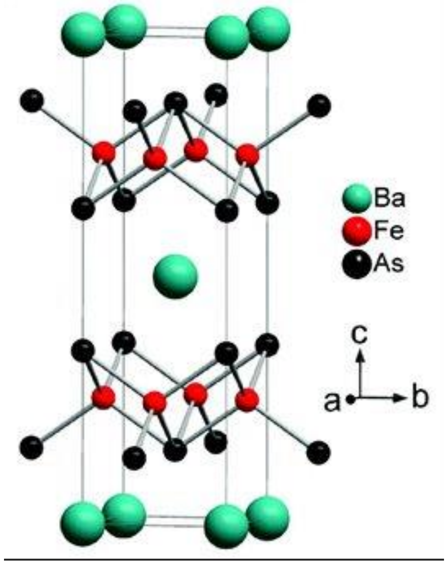
Z. Phys. B – Condensed Matter 64, 189–193 (1986)

Transition has finite width ➔ material purity

In zero field, ideally sharp transition versus T

$BaFe_{1.29}Ru_{0.71}As_2$





Supercond. Sci. Technol. **26** (2013) 015009

Volume 10, Number 3 PHYSICAL REVIEW LETTERS 1 February 1963

OBSERVATION OF PERSISTENT CURRENT IN A SUPERCONDUCTING SOLENOID

J. File and R. G. Mills
Plasma Physics Laboratory, Princeton University, Princeton, New Jersey

(Received 21 September 1962; revised manuscript received 26 December 1962)

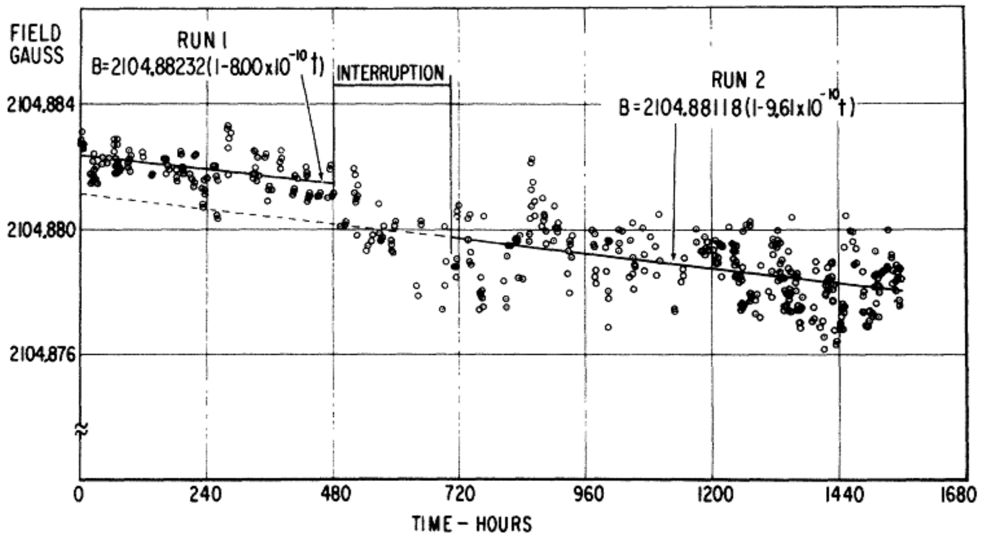


FIG. 3. Experimental data for runs one and two.

$\rho < 5 \times 10^{-22}\ \Omega\ cm$

Nb-25%Zr alloy
NMR detection of field

PHYSICAL REVIEW VOLUME 181, NUMBER 2 10 MAY 196

Flux Creep in Type-II Superconductors

M. R. Beasley,* R. Labusch,† and W. W. Webb

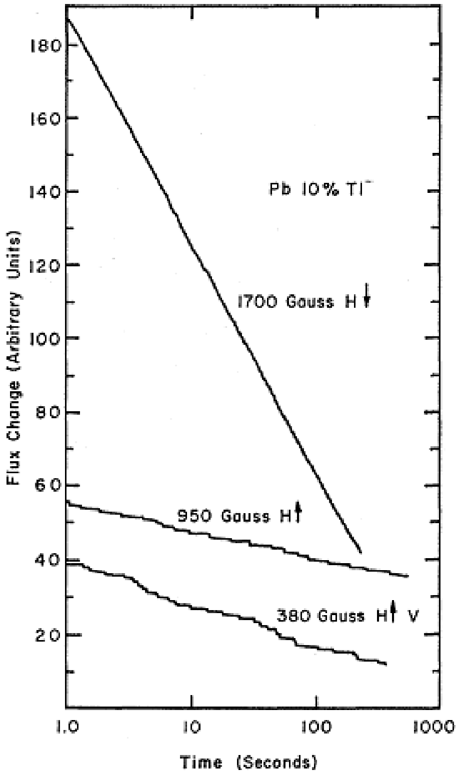
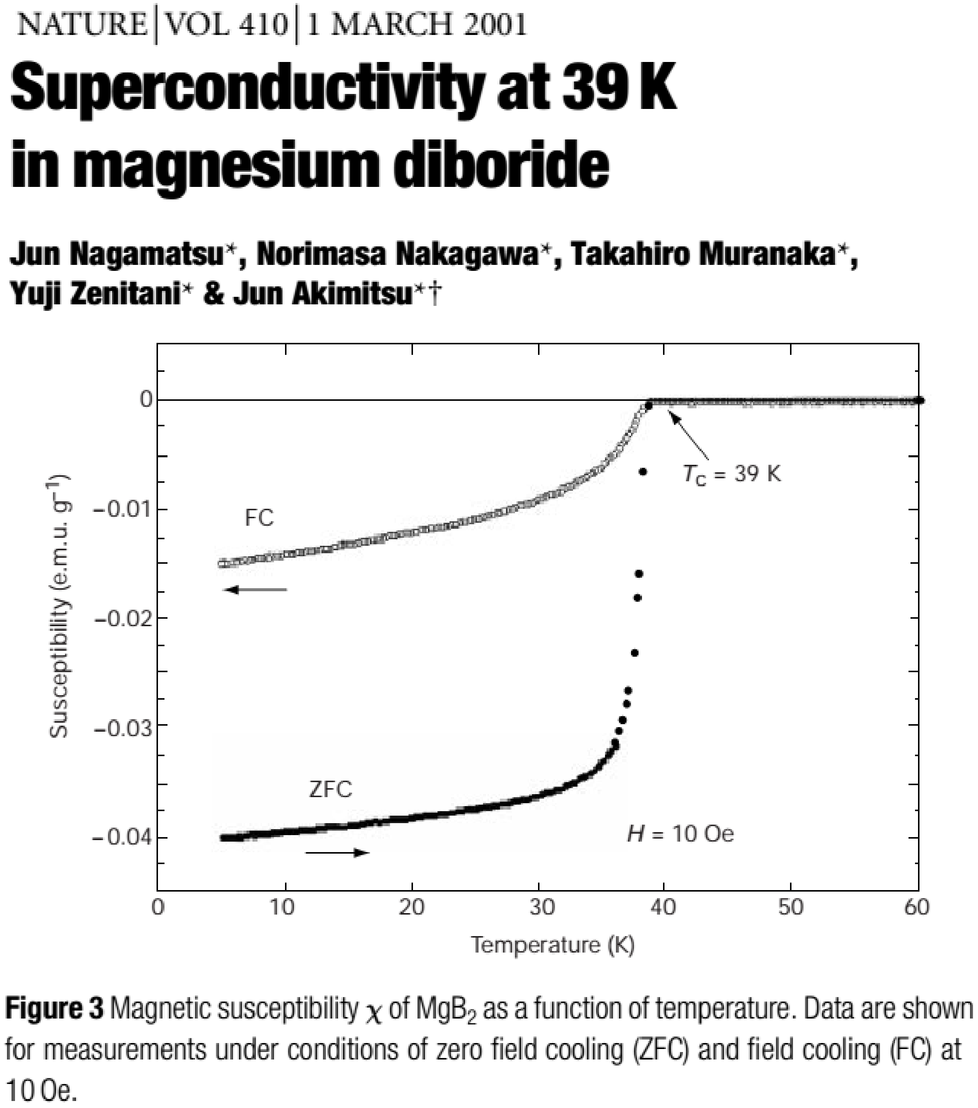


Fig. 5. *X-Y* recording of flux change versus ln *t*. Typical behavior at high and low fields for creep on the initial magnetization curve (indicated by *V*). In this record the vertical steps are due only to the digital nature of the signal processing (each step indicates the completion of a full cycle in the magnetometer output) and are not due to discontinuous flux changes in the sample. The arrows indicate whether *H* was increasing or decreasing.

Pb-Tl alloy
SQUID detection of field

Perfect diamagnet



NATURE | VOL 410 | 1 MARCH 2001

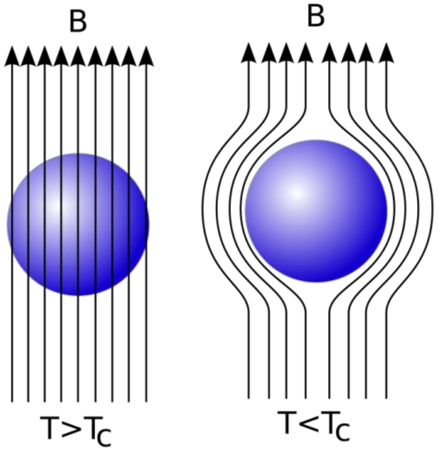
Superconductivity at 39 K in magnesium diboride

Jun Nagamatsu*, Norimasa Nakagawa*, Takahiro Muranaka*, Yuji Zenitani* & Jun Akimitsu*†

Figure 3 Magnetic susceptibility χ of MgB_2 as a function of temperature. Data are shown for measurements under conditions of zero field cooling (ZFC) and field cooling (FC) at 10 Oe.

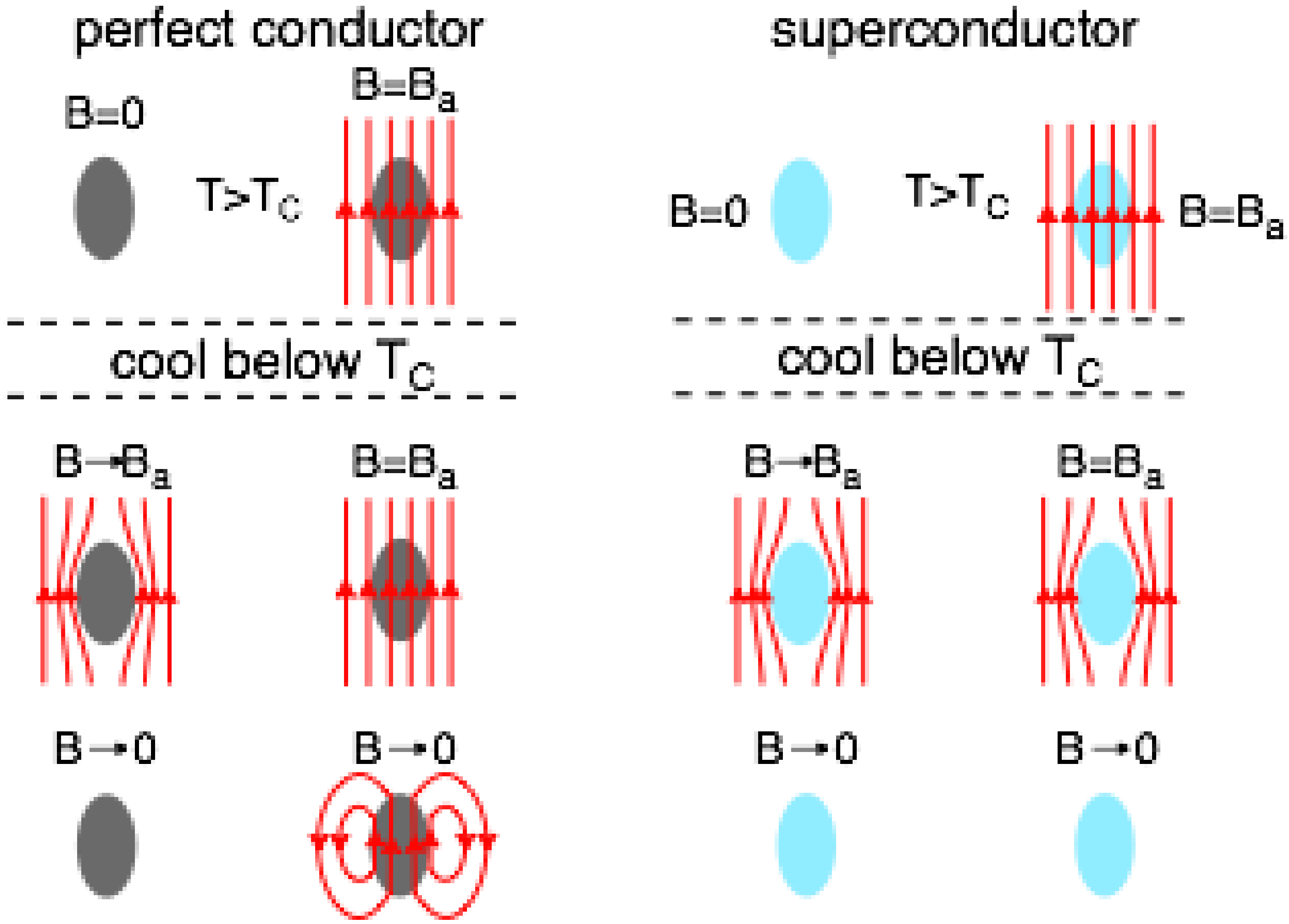
Walter Meissner

Robert Ochsenfeld



TYPE I

Meissner effect



Critical field (type I)

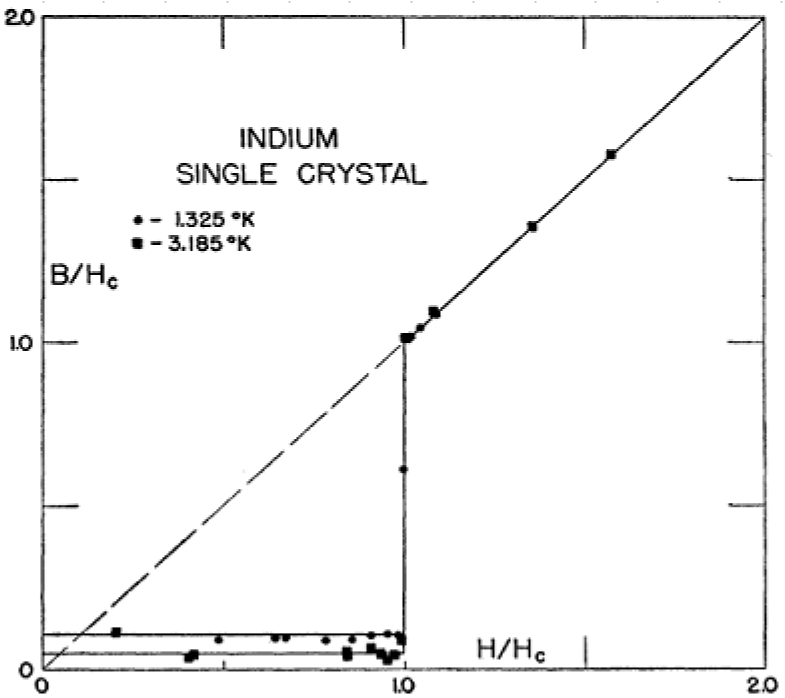


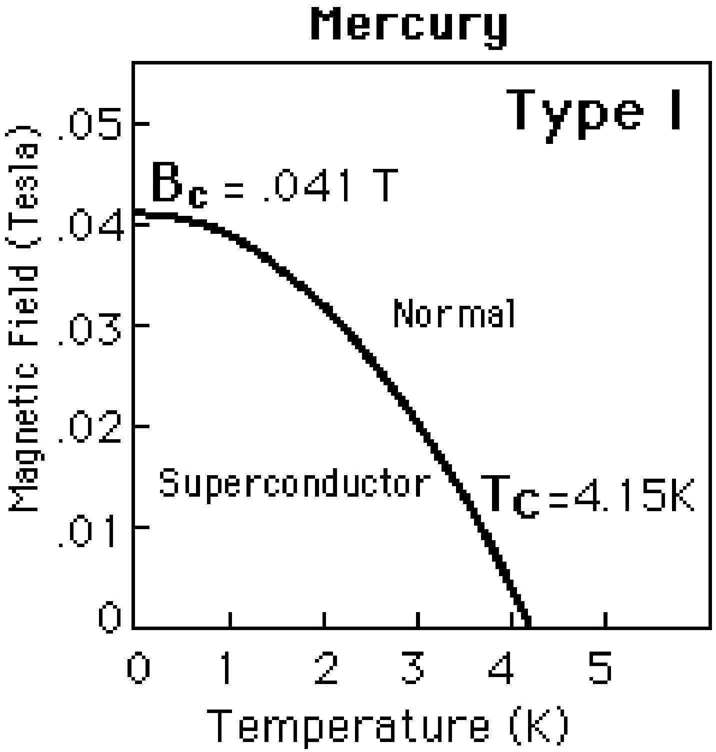
FIG. 2. Reduced magnetic induction *versus* reduced field.

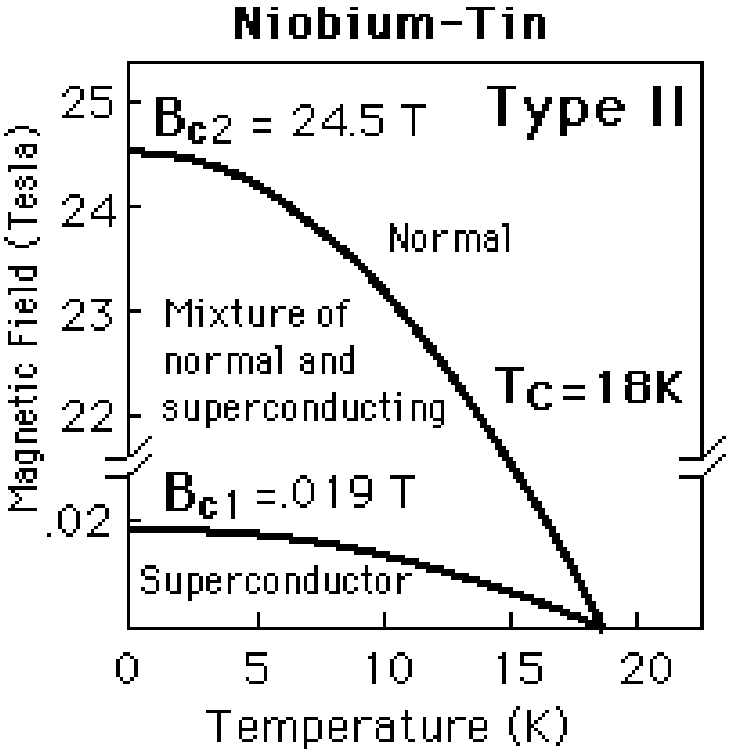
Stout&Guttman, Phys.Rev. 88, 704 (1952)

Building up magnetization costs E
When E >= $E_{condensate}$: phase transition

Indium
T_c = 3.4 K
H_c = 284 gauss

Magnetic field dependence



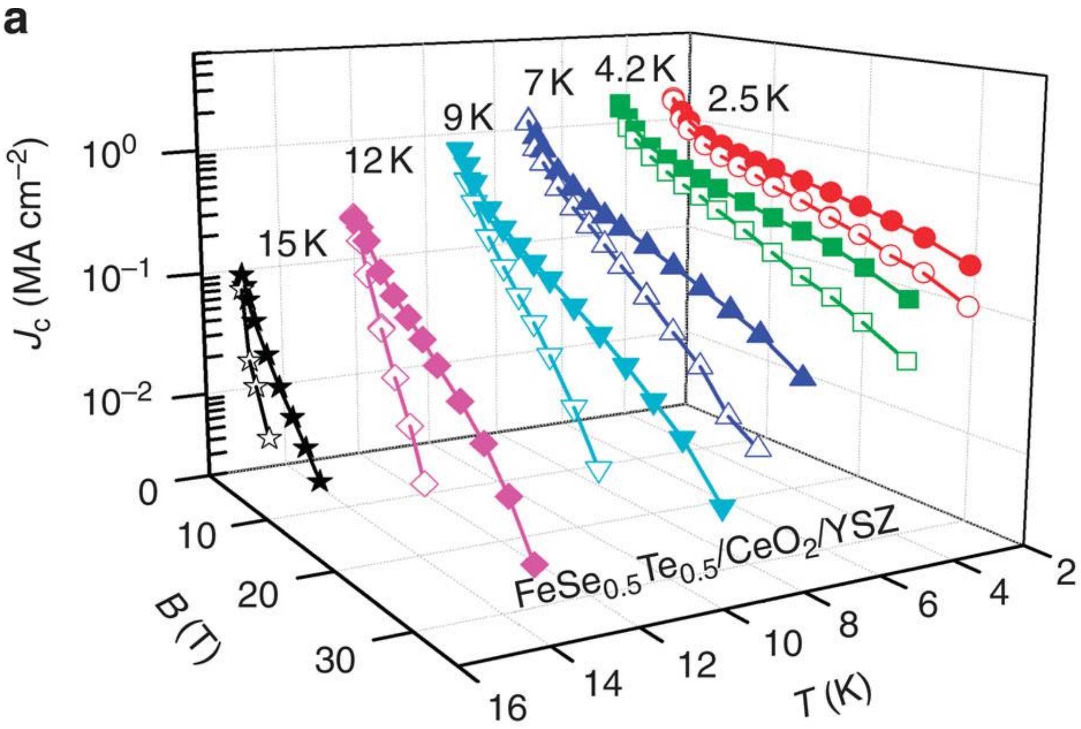


Empirical relation

$$H_c(T) = H_c(0)\left[1 - \left(\frac{T}{T_c}\right)^2\right]$$

Typical value < 0.3 T
Not good for applications

Critical current



Jc of FST films on (a) a YSZ substrate with a CeO2 buffer layer and (b) a RABiTS substrate at various temperatures with magnetic field parallel (solid symbols) and perpendicular (open symbols) to the ab plane (tape surface). The self-field Jc of both films are above 1 MA cm−2 at 4.2 K. Under 30 T of magnetic fields, both films still carry Jc around 1 × 105 A cm−2.

Si et al., Nat. Comm. 4, 1347 (2013).

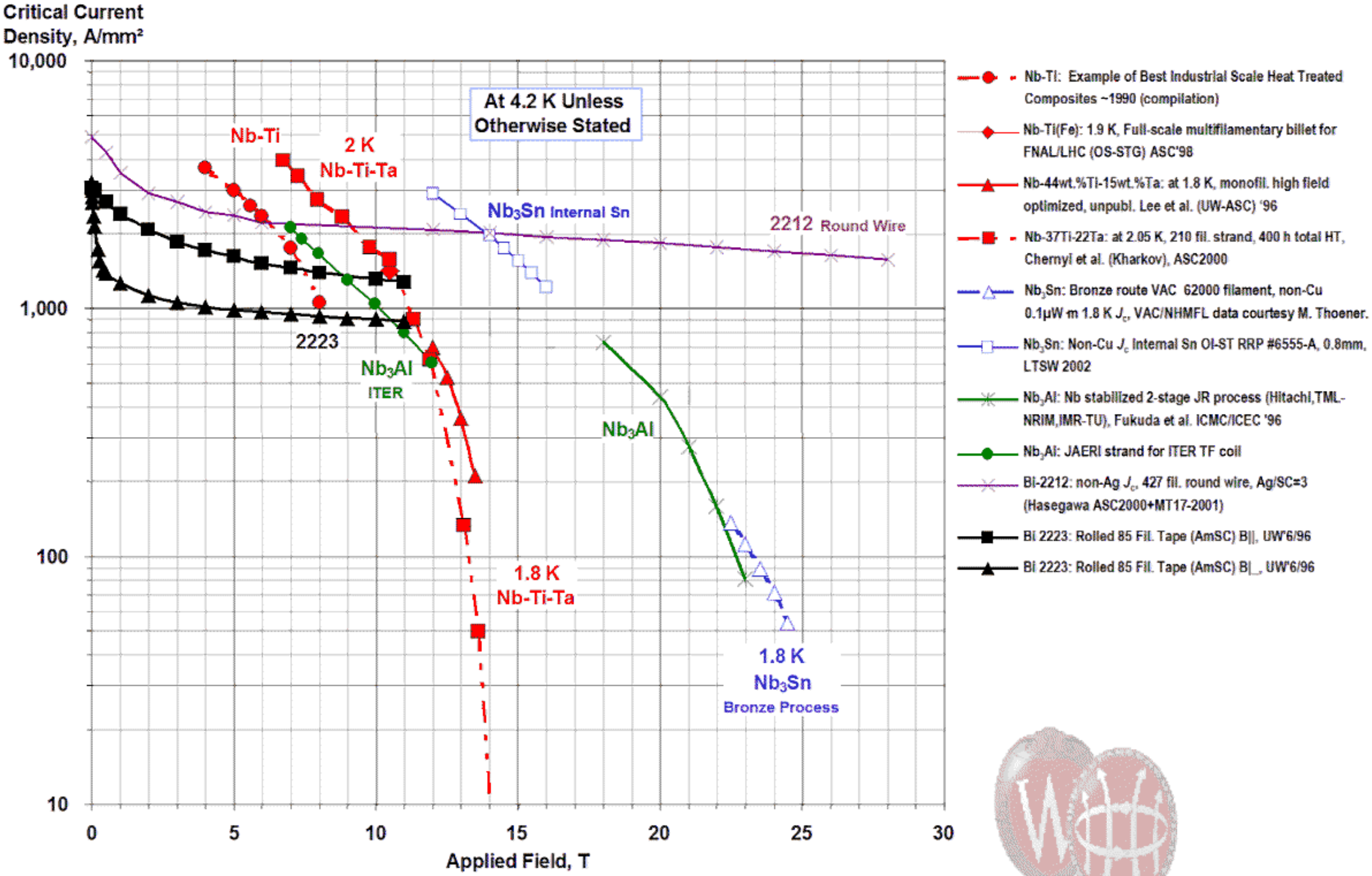
Silsbee rule (1916):

$$I_c = 2\pi R\ H_c$$

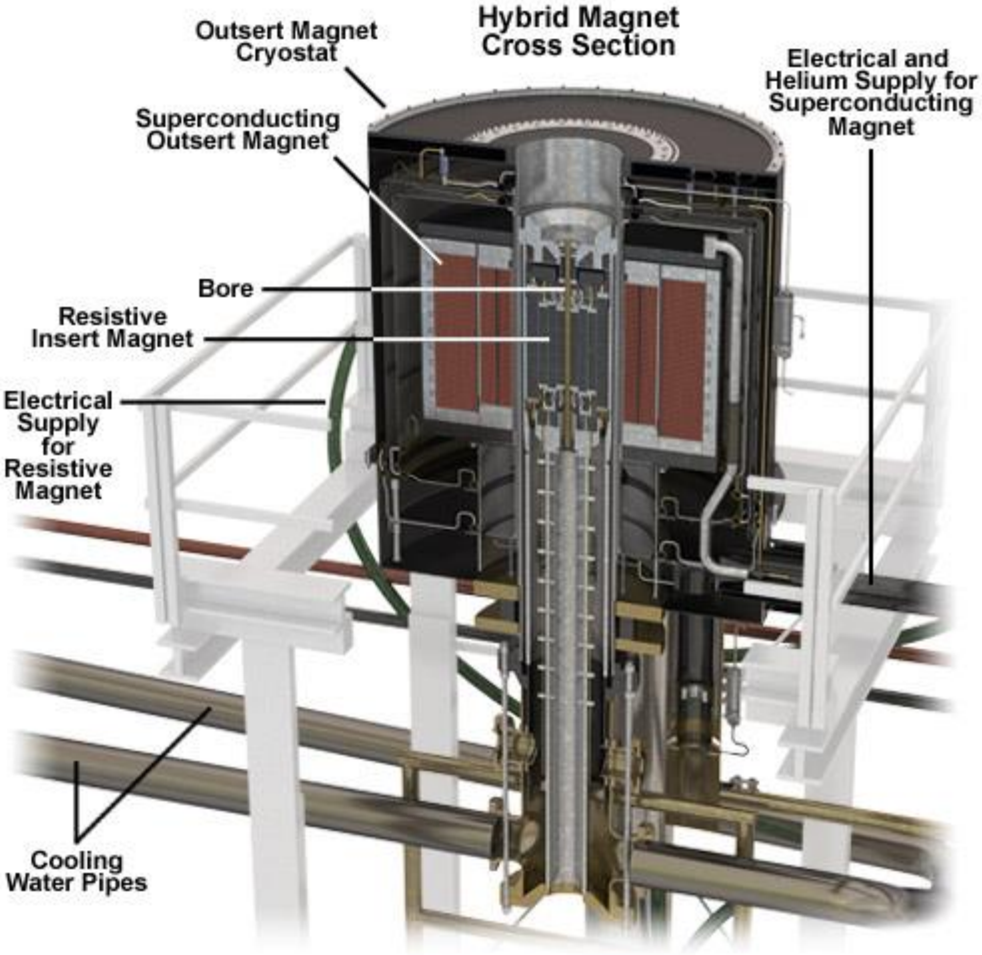
Ring, radius R. Field $I/2\pi R$

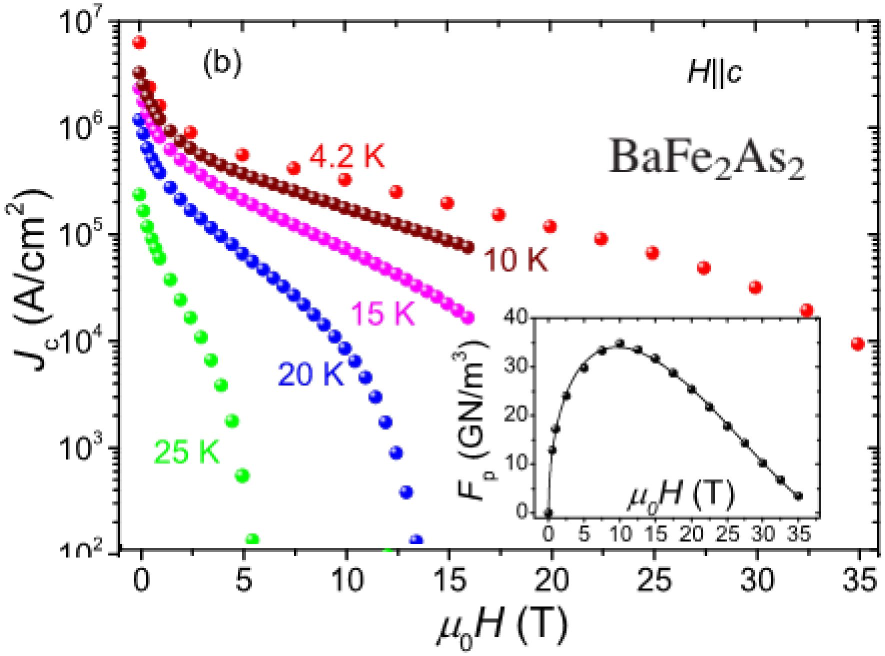
Advancing Critical Currents in Superconductors

University of Wisconsin-Madison
Applied Superconductivity Center
December 2002 - Compiled by Peter J. Lee



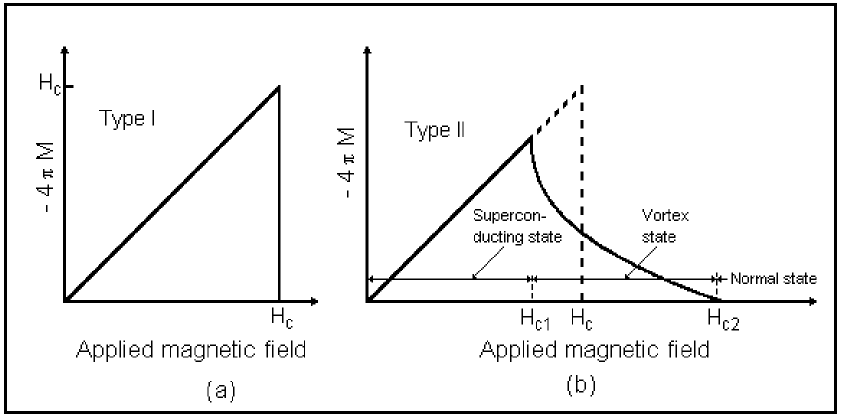
45 T Hybrid magnet
Resistive: 33.5 T
SC coil: 11.5 T



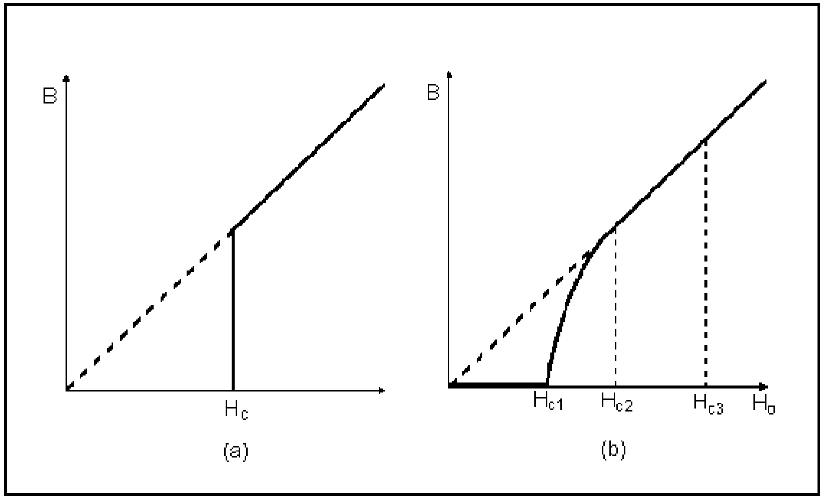


Kurth et al., APL 106, 072102 (2015)

Type I & II superconductors

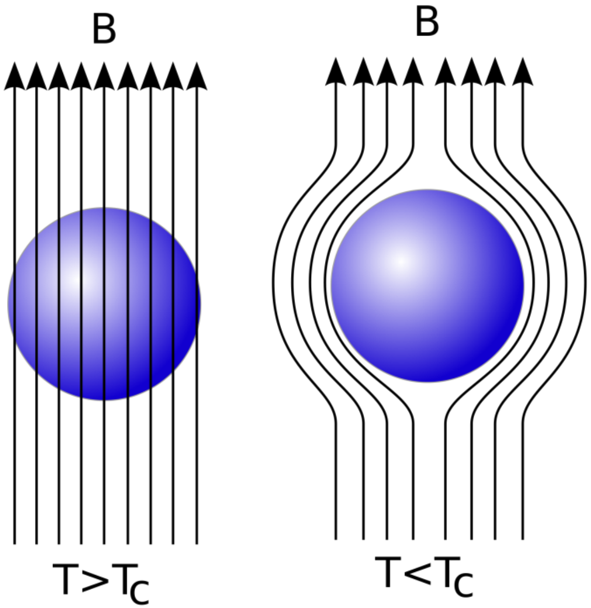


Magnetization M

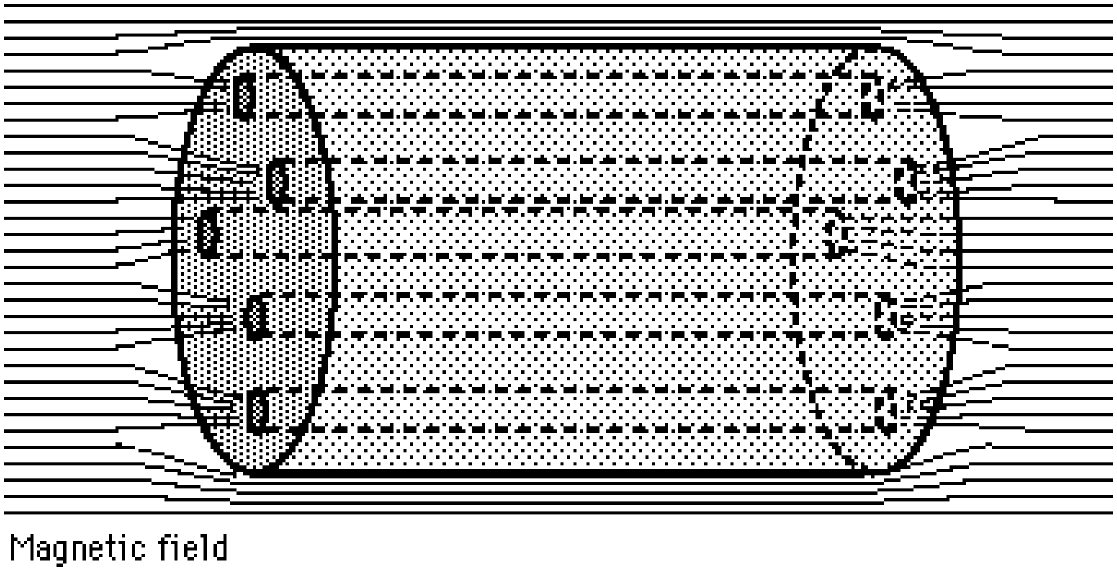


Magnetic induction B

Type II superconductors



TYPE I



TYPE II
(shubnikov phase)

Flux lines, Abrikosov lattice

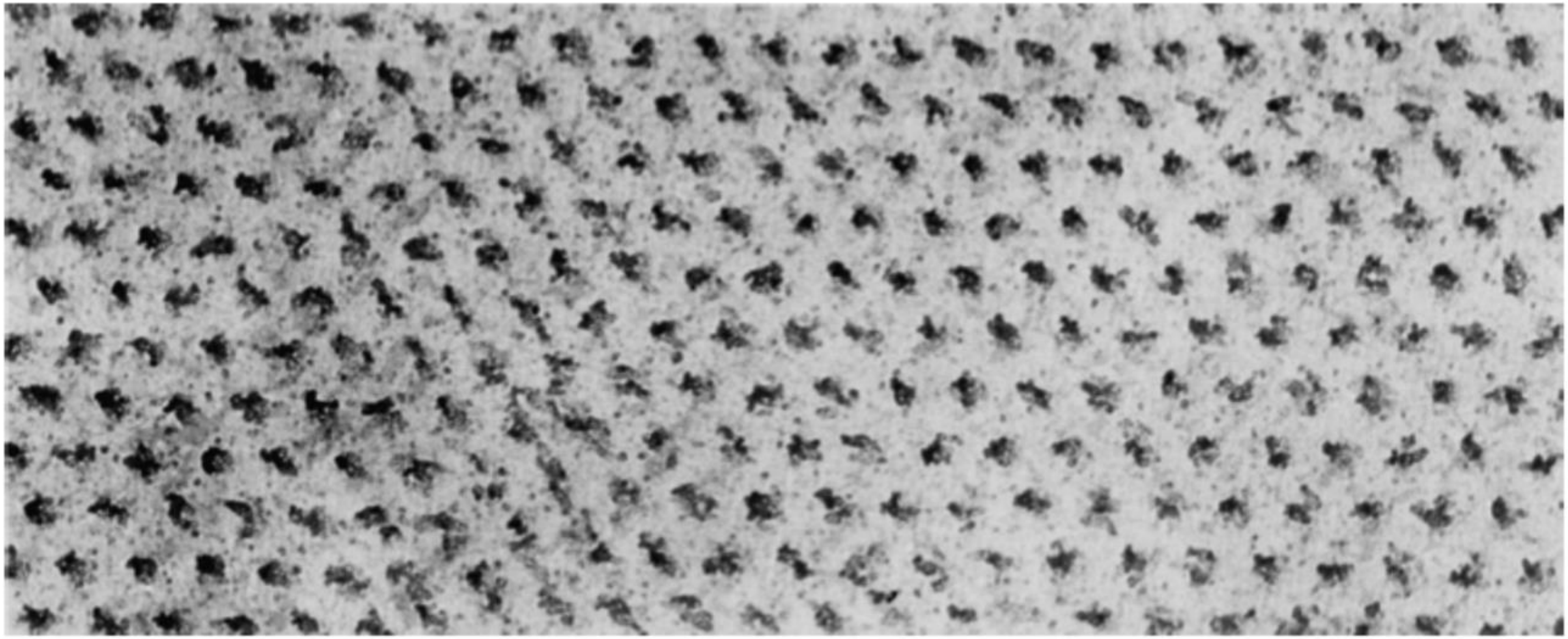


Fig. 1.9 Image of the vortex lattice obtained with an electron microscope following the decoration with iron colloid. Frozen-in flux after the magnetic field has been reduced to zero. Material: Pb + 6.3 at.% In; temperature: 1.2 K; sample shape: cylinder, 60 mm long, 4 mm diameter; magnetic field $\mathbf{B}_a$ parallel to the axis. Magnification: 8300×. (Reproduced by courtesy of Dr. Essmann).

Lattice: 1-100 nm