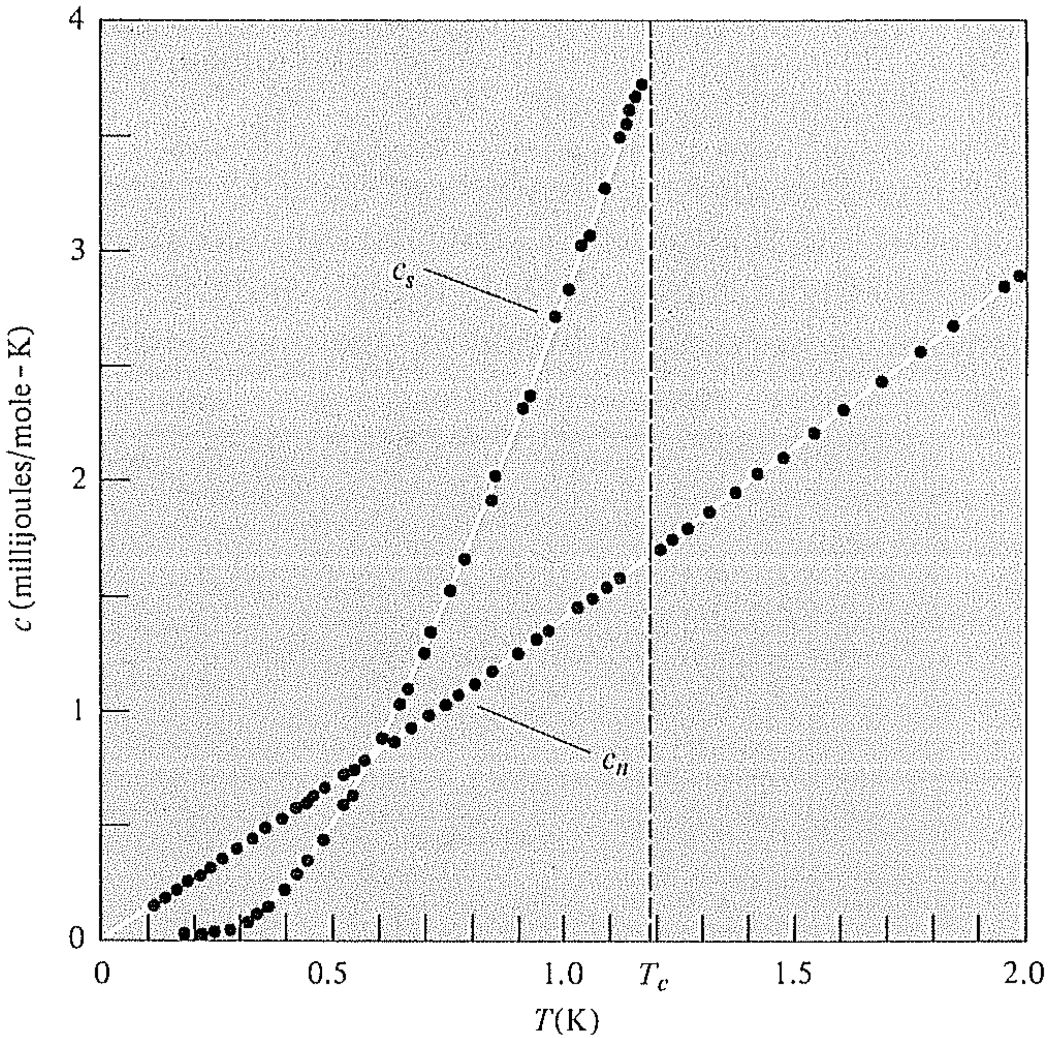
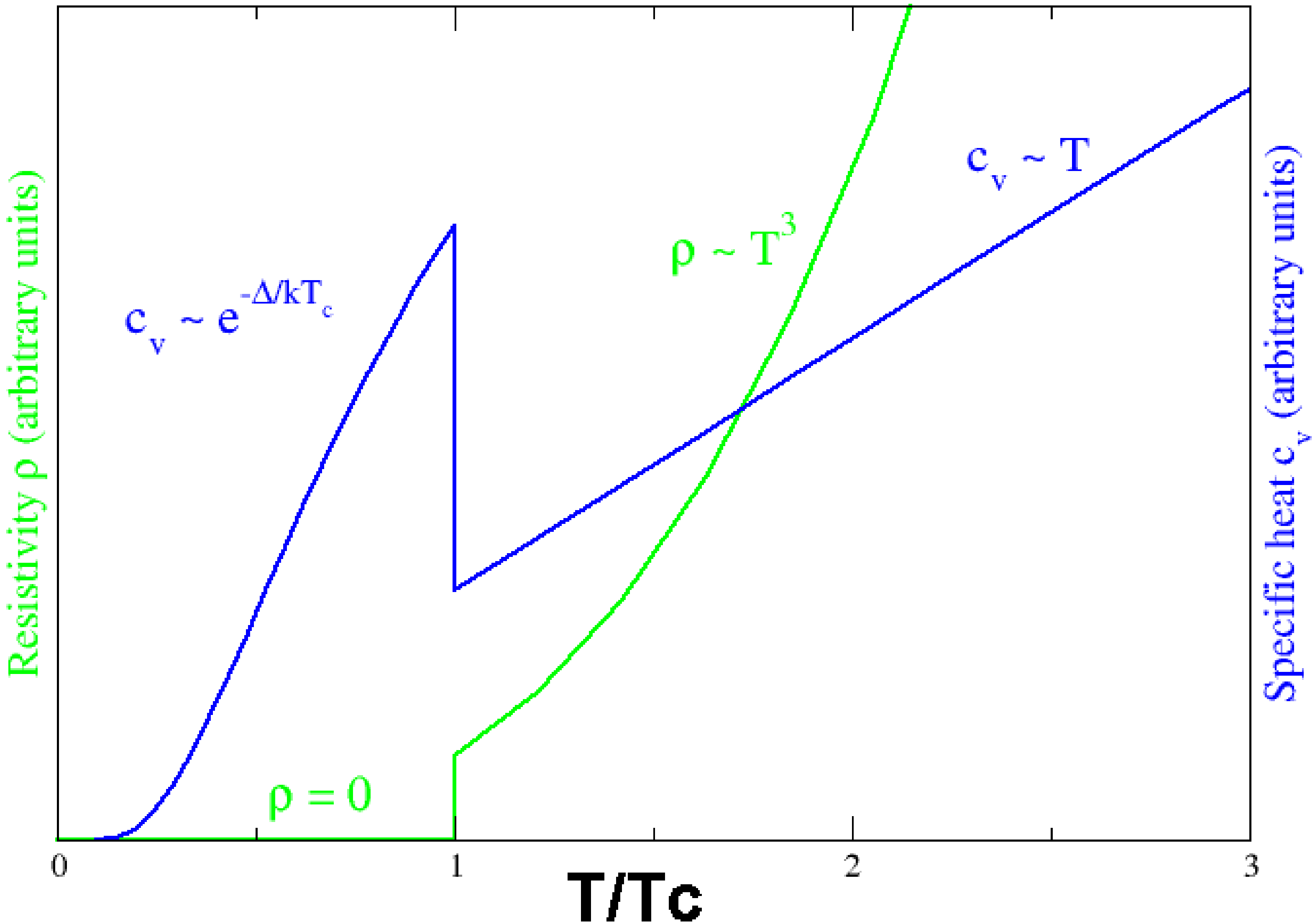
The Thermodynamics of Superconductors

Low Temperature Specific Heat of Aluminum



Low-temperature specific heat of normal and superconducting aluminum. The normal phase is produced below T_c by application of a weak (300-gauss) magnetic field, which destroys the superconducting ordering but has otherwise negligible effect on the specific heat. The Debye temperature is quite high in aluminum, so the specific heat is dominated by the electronic contribution throughout this temperature range (as can be seen from the fact that the normal-state curve is quite close to being linear). The discontinuity at T_c agrees well with the theoretical prediction (34.22) $[c_s - c_n]/c_n = 1.43$. Well below T_c, c_s drops far below c_n, suggesting the existence of an energy gap. (N. E. Phillips, *Phys. Rev.* **114**, 676 (1959).)

Ashcroft and Mermin, p. 734



http://en.wikipedia.org/wiki/Superconductivity

The 'Universal' Heat Capacity Jump at T_c

MEASURED VALUES OF THE RATIO[a] $[(c_s - c_n)/c_n]_{T_c}$

ELEMENT	$\left[\frac{c_s - c_n}{c_n}\right]_{T_c}$
Al	1.4
Cd	1.4
Ga	1.4
Hg	2.4
In	1.7
La (HCP)	1.5
Nb	1.9
Pb	2.7
Sn	1.6
Ta	1.6
Tl	1.5
V	1.5
Zn	1.3

[a] The simple BCS prediction is $[(c_s - c_n)/c_n]_{T_c} = 1.43$.
Source: R. Mersevey and B. B. Schwartz, *Superconductivity*, R. D. Parks, ed., Dekker, New York, 1969.

The prediction holds for weak-coupled SCs

Ashcroft and Mermin, p. 747

Electronic Entropy of Normal Metal and Superconductor

Obtain S from integrating C_V over T

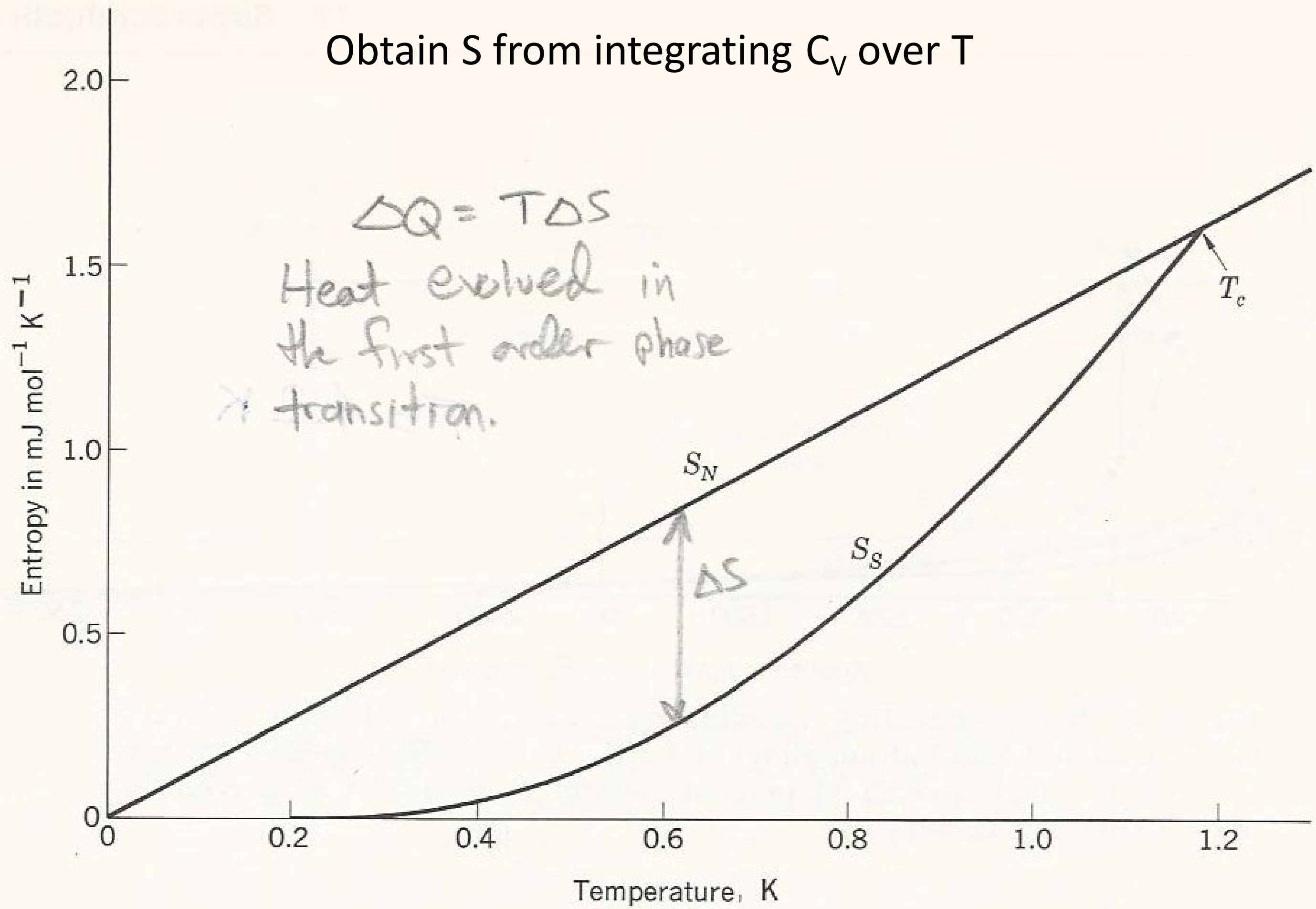


Figure 7a Entropy S of aluminum in the normal and superconducting states as a function of the temperature. The entropy is lower in the superconducting state because the electrons are more ordered here than in the normal state. At any temperature below the critical temperature T_c the specimen can be put in the normal state by application of a magnetic field stronger than the critical field.

C. Kittel, Solid Introduction to State Physics, 5th Edition, page 364.

Free Energy of Normal Metal and Superconductor

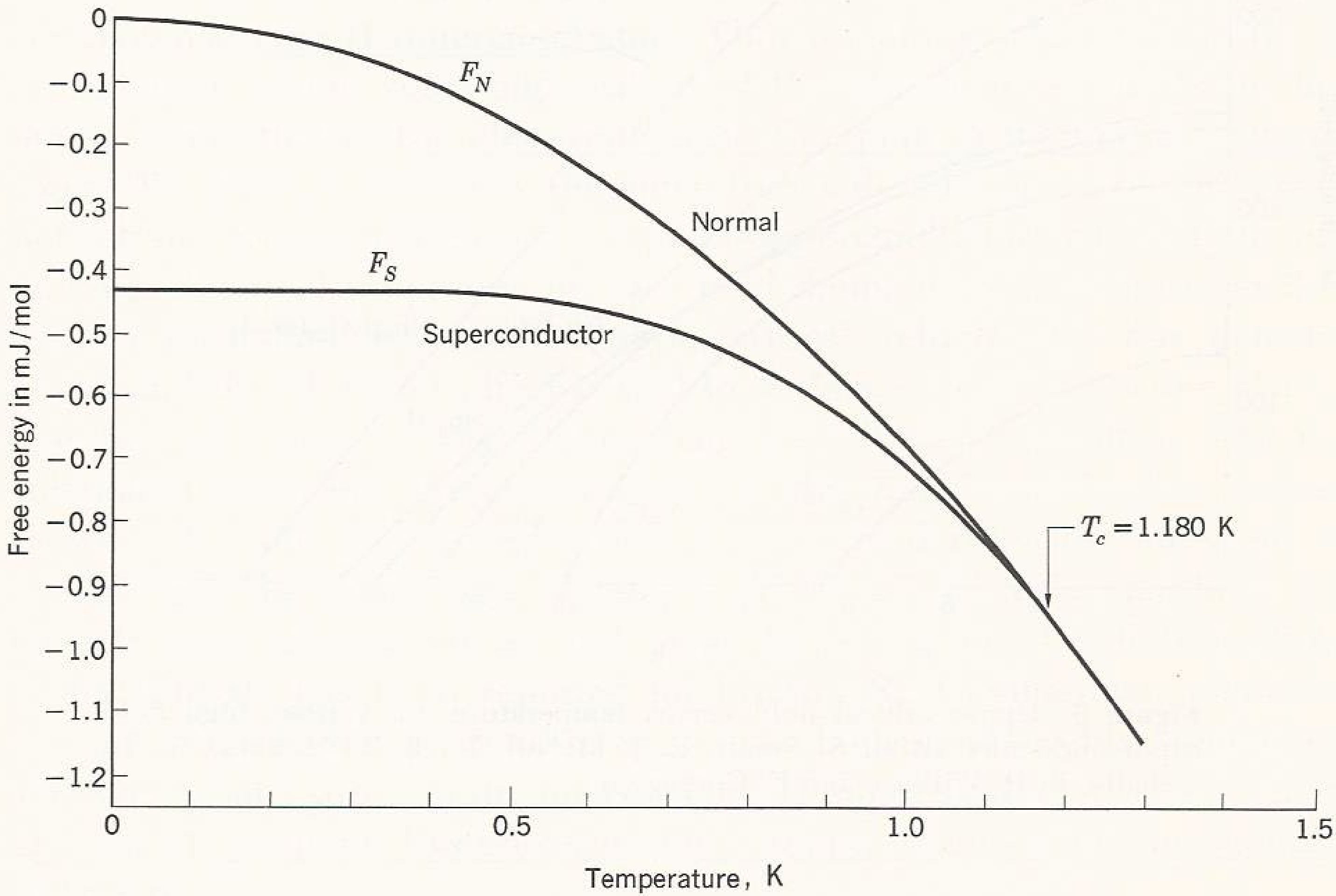
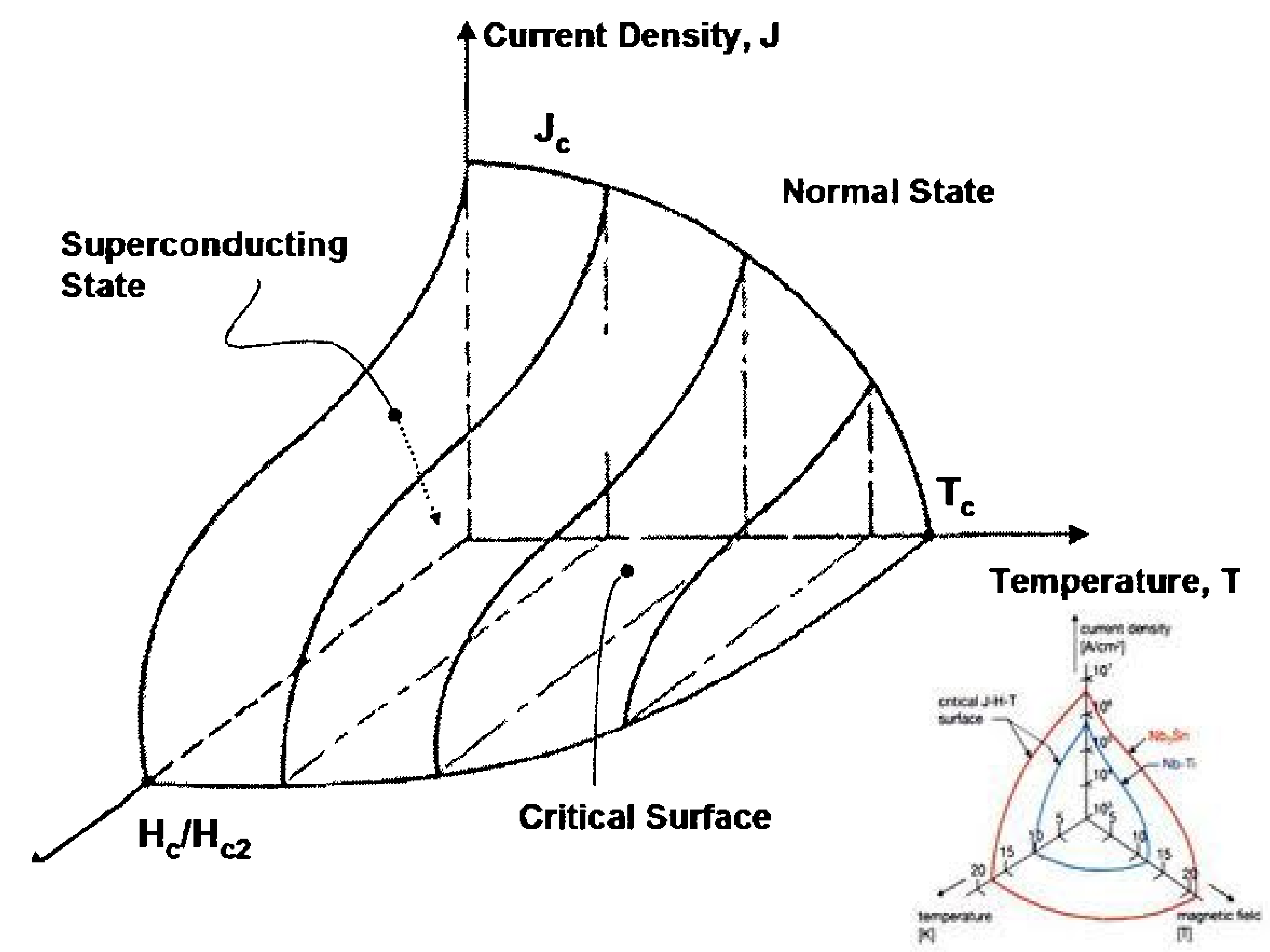


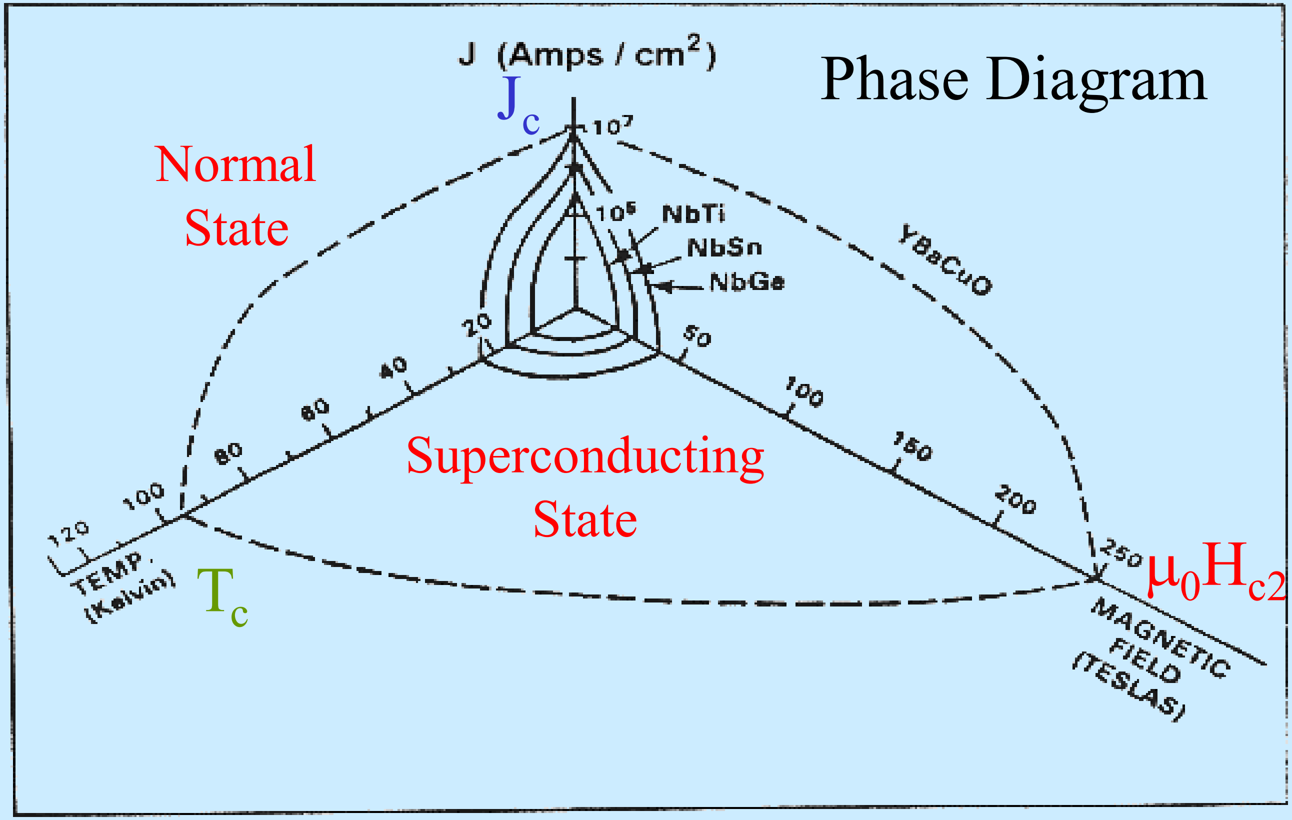
Figure 7b Experimental values of the free energy as a function of temperature for aluminum in the superconducting state and in the normal state. Below the transition temperature $T_c = 1.180$ K the free energy is lower in the superconducting state. The two curves merge at the transition temperature, so that the phase transition is second order (there is no latent heat of transition at T_c). The curve F_S is measured in zero magnetic field, and F_N is measured in a magnetic field sufficient to put the specimen in the normal state. (Courtesy of N. E. Phillips.)

C. Kittel, Solid Introduction to State Physics, 5th Edition, page 364.

The Limits of Superconductivity


Current Density, J
J_c
Normal State
Superconducting State
T_c
Temperature, T
H_c/H_c2
Critical Surface
current density
critical J-H-T surface
temperature
magnetic field

What are the Limits of Superconductivity?



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