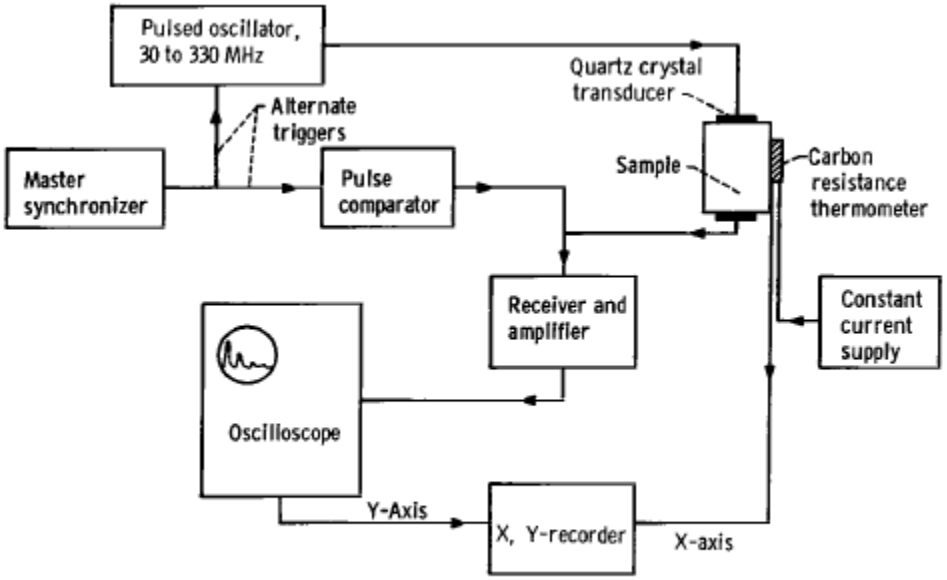
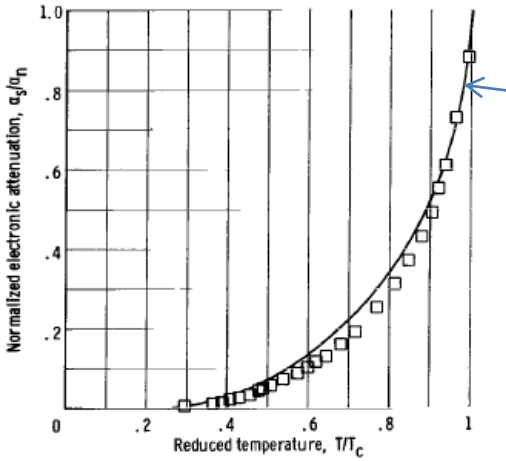
Ultrasonic Attenuation Measurement



J. H. Simmons
NASA TN D-3817

Figure 2. - Block diagram of ultrasonic equipment used in observing attenuation in niobium.

Inject a pulse of ultrasound into the sample and measure its amplitude as a function of time as it reverberates

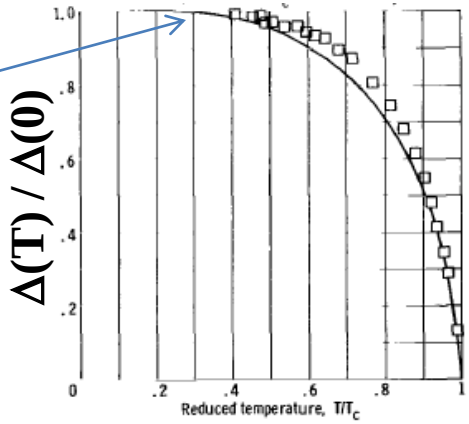


(c) Propagation in (110) crystal direction; sample resistance ratio, 1330; ultrasonic frequency, 330 megahertz.

BCS Theory

$$\frac{\alpha_s}{\alpha_n} = \frac{2}{\exp\left[\frac{\Delta(T)}{k_B T}\right] + 1}$$

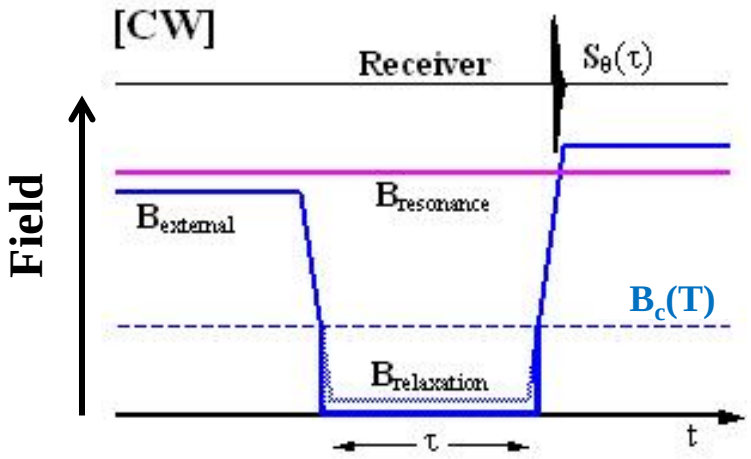
Nb single crystal



(c) Propagation in (110) crystal direction; resistance ratio, 1330; zero-temperature energy gap, 1.84 $k_B T_c$, where k_B is Boltzmann constant and T_c is critical temperature.

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19670007363_1967007363.pdf

Measurement of the Hebel-Slichter Peak
Fast-Field-Cycling NMR Relaxometry



RF frequency = 400 kHz
Resonant field for ^{27}Al = 36 mT
Polarizing field = 45-50 mT
Al: $H_c(0)$ = 10.5 mT

Consider Al, type-I superconductor

Step 1: Polarize the nuclear spins with $B_{external} > B_c(T)$ at $T < T_c$. This establishes nuclear magnetization $\mathbf{m}(B_{external},T)$

Step 2: Remove the field quickly (FFC) on a time scale $\Delta t << T_1$. $B \rightarrow B_{relaxation} \approx 0$.

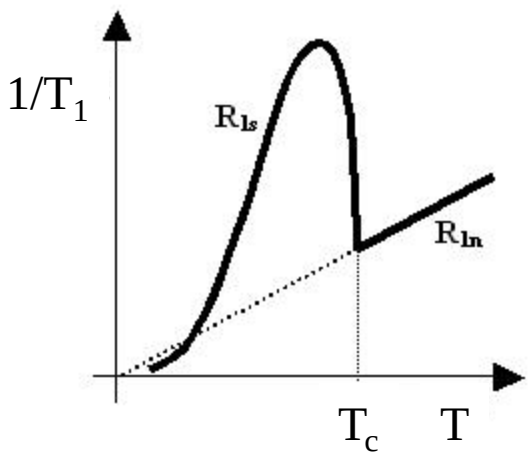
Step 3: Allow the nuclear spins to relax by interacting with the Bogoliubons for time τ. Spin flips occur…

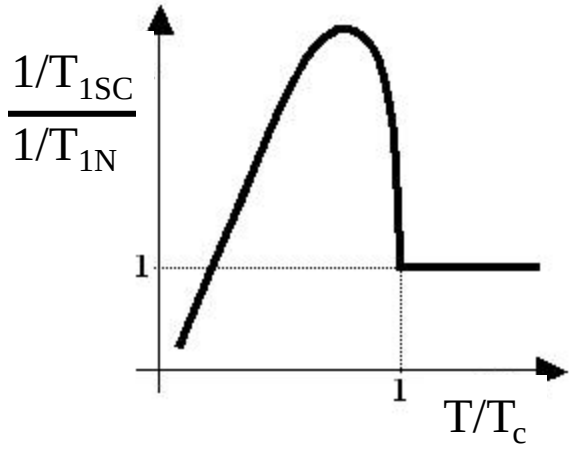
Step 4: Quickly re-apply a large field $B > B_c(T)$ and $B > B_{resonance}$, and measure $\mathbf{m}(B=0,T)$.
$\mathbf{m}(B=0,T)$ measured as B passes through the nuclear resonance field and creates a brief signal $S_\theta(\tau)$

$$\frac{dm(t)}{dt} = -\frac{m(B=0,t) - m(B_{external},t)}{T_1}$$

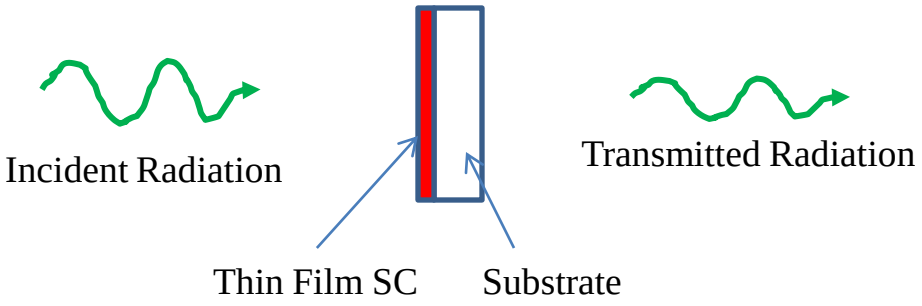
http://www.ebyte.it/library/educards/nmr/Nmr_HebelSlichter.html

Measurement of the Hebel-Slichter Peak





Measurement of Electromagnetic Absorption



For films thin compared to skin depth and penetration depth:

$$\frac{T_S}{T_N} = \left\{ \left[T_N^{\frac{1}{2}} + (1 - T_N^{\frac{1}{2}}) \frac{\sigma_1}{\sigma_N} \right]^2 + \left[(1 - T_N^{\frac{1}{2}}) \frac{\sigma_2}{\sigma_N} \right]^2 \right\}^{-1}$$

Energy Gap Interpretation of Experiments on Infrared Transmission through Superconducting Films*

M. Tinkham

(Received September 4, 1956)

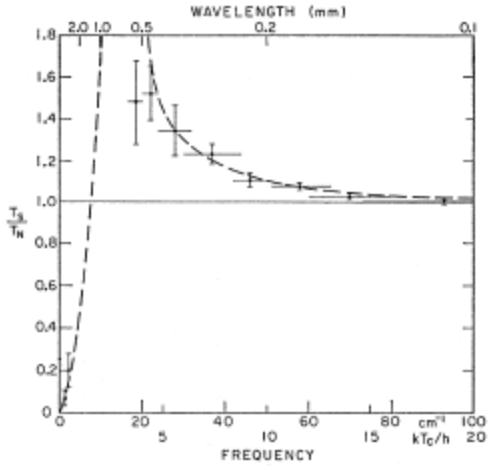


FIG. 1. Experimental transmission ratios of superconducting and normal states of a typical lead film (dc residual resistance 117 ohms; transmission in normal state = ½) at $T/T_c = 0.67 \pm 0.03$. The frequency uncertainty on each infrared point is the half-power width of the continuous spectrum used. The vertical error limits on these points are derived statistically from the data. The dashed curve is one proposed for $T = 0$ and an energy gap of $3kT_c$, as described in the following Letter.

Transmission of Superconducting Films at Millimeter-Microwave and Far Infrared Frequencies*

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