PRESSURE DEPENDENCE OF THE ENERGY GAP OF SUPERCONDUCTING Pb†

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The electron-phonon coupling strength in Pb, as measured by the "gap ratio" $2\Delta_0/kT_c$, decreases with increasing pressure.

We report here the results of a study of the gap (at the gap edge) Δ, the transition temperature T_c, and the "gap ratio" $2\Delta_0/kT_c$ of Pb as a function of pressure and temperature. These results were obtained from electron-tunneling measurements on Pb-insulator-Al junctions subjected to approximately hydrostatic pressures in solid helium. A study of Grüneisen gammas of Pb by this method has been reported previously[1] and showed the feasibility of the method.

The Pb-insulator-Al junctions were prepared by conventional methods on microscope slides. The junctions were mounted in a pressure cell and could be pressurized by freezing helium at constant pressure. The pressure at the working temperatures ($\lesssim 7$°K) was determined by the method described in Ref. 1 and was known to ±6%. Pressures up to 3400 bar were used. The pressure cell could be thermally isolated from the bath, its temperature could be lowered to 1.4°K by pumping on a small helium reservoir or raised above the bath temperature by electrical heating. The cell temperature was determined with a germanium thermometer to ±0.1%.

Direct measurements of di/dv were made by an ac bridge technique. We obtained the gap $\Delta(T)$ from these measurements by fitting the normalized conductance $(di/dv)_s/(di/dv)_n$ at zero bias to Bermon's[2] calculations for the BCS superconductor. We believe that this choice gives very nearly the gap at the gap edge. This method, however, becomes increasingly inaccurate at low reduced temperatures and was therefore only used for $t \geq 0.55$. The measurements were supplemented by a direct determination of the gap at 2.0°K, giving very nearly the zero-temperature energy gap Δ_0.

The transition temperature T_c of the films was obtained by noting the disappearance of the gap in di/dv; its uncertainty is estimated at ±0.15%.

The results for one particular junction are shown in Fig. 1; similar, although not as extensive, data were obtained for eight other junctions. The zero-pressure curve was measured before and after the pressure run and found to be reproducible. Figure 2 shows the same results in reduced form as $[\Delta(T)/kT_c]^2$ vs $t = T/T_c$.

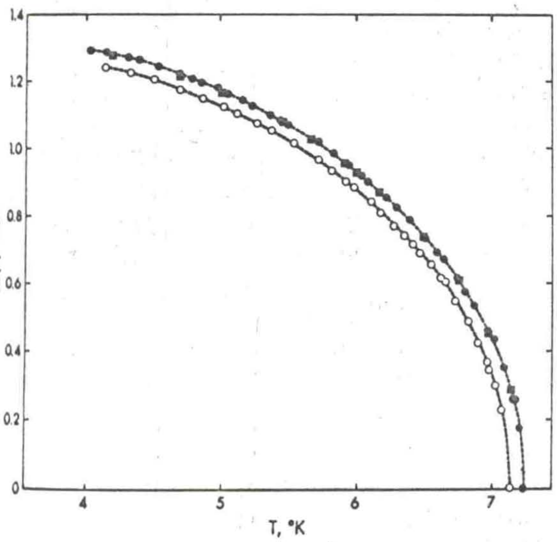

FIG. 1. Energy gap (at the gap edge) of Pb as a function of temperature. Order of runs: black dots ($P=0$); open circles ($P=2730$ bar); black squares ($P=0$).

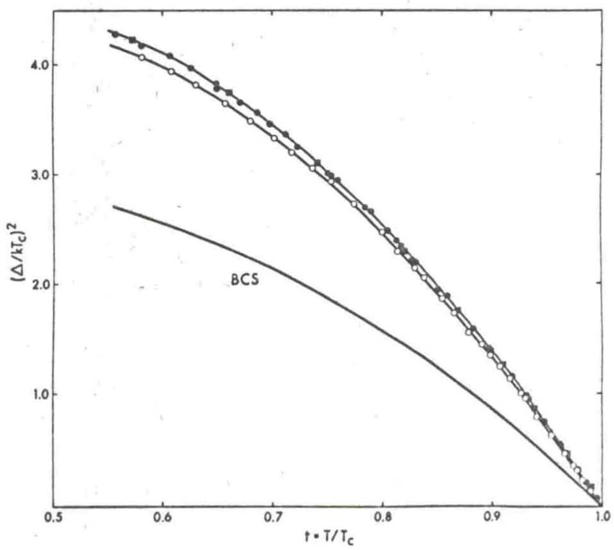

FIG. 2. Squared reduced energy gap (at the gap edge) of Pb as a function of reduced temperature. Black dots and squares, $P=0$; open circles, $P=2730$ bar.