Thermal Conductivity in the Intermediate State of Pure Superconductors*

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IN 1950 Mendelssohn and Olsen[1,2] measured the thermal conductivity of niobium and a lead-bismuth alloy (0.1 percent Bi). Their measurements showed a thermal conductivity minimum and marked hysteresis effects in the intermediate state. Webber and Spohr[3] have found similar effects in pure lead below about 4° Kelvin.

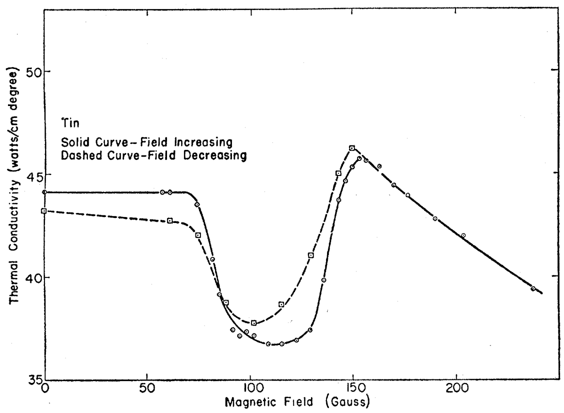

FIG. 1. The thermal conductivity of tin in a transverse magnetic field at 2.5°K.

Measurements carried out in this laboratory of the thermal conductivity of Johnson-Matthey spectroscopically pure tin and indium as a function of transverse magnetic field strength suggest that this phenomenon may be characteristic of all pure superconductors. (See Figs. 1 and 2.) The specimens used were 3 to 4 mm in diameter and approximately 10 cm long, and consisted of a few large crystals. The temperature gradient was determined with carbon composition resistors. A total temperature difference between the thermometers of approximately 0.05°K was used, so that the critical field was practically identical throughout the specimen.

In both these materials a very distinct minimum occurs in the thermal conductivity in the intermediate state, along with strong magneto-resistance for fields greater than critical, as shown by the figures. This characteristic behavior was observed at several temperatures below the zero-field transition temperature. The fact that our indium specimen exhibits a very much higher conductivity than that of Hulm[4] is probably due to its much greater purity.

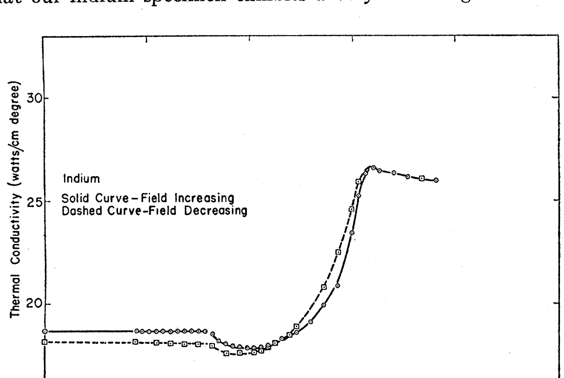

FIG. 2. The thermal conductivity of indium in a transverse magnetic field at 2.1°K.

If the heat transport in the superconducting state is primarily due to electrons as it appears to be in the normal state for both tin and indium, it is reasonable to attribute the minimum in the thermal conductivity to the scattering of electrons by the laminar structure of the intermediate state as suggested by Webber and Spohr.[3] On the other hand, if the lattice conduction has become appreciable in the superconducting state the intermediate state minimum may be due to the scattering of lattice waves by the laminar boundaries.[5] Whichever mechanism proves to be correct, it is likely that further investigation along these lines will lead to a fuller understanding of the structure of the intermediate state.

A detailed account of these experiments will be published later.

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‡ This material is part of a dissertation presented to the faculty of Yale University in partial fulfillment of the requirements for the Ph.D. degree.
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5 We are indebted to J. K. Hulm and R. T. Webber for a discussion of this point.

Angular Correlation between γ-Rays and Inelastically Scattered Protons from Mg^{24} †

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THE 7.3-Mev proton beam from the M.I.T. cyclotron has been used to bombard a magnesium target in a scattering chamber which has been described previously.[1] The correlation between the inelastically scattered protons from Mg^{24} (78 percent abundance) leaving the nucleus in the 1.4-Mev state[2] and the subsequent gamma-ray has been investigated in a preliminary way.

The protons were detected in the first section of a triple proportional counter[1] using range absorption and the method of peaking. The counter could be rotated from 30° to 145° with respect to the proton beam. The gamma-counter, which consisted of a cylindrical NaI crystal two inches in diameter and one inch thick mounted on a 5819 photomultiplier, was coplanar with the beam and the scattered protons. Only the two positions of −30° and −90° to the beam were available for the gamma-counter. The NaI crystal subtended a solid angle of about 2 percent of a sphere at the target. It was shielded around the sides with about two inches of lead to reduce background. No energy selection was attempted except for low level discrimination to eliminate noise and

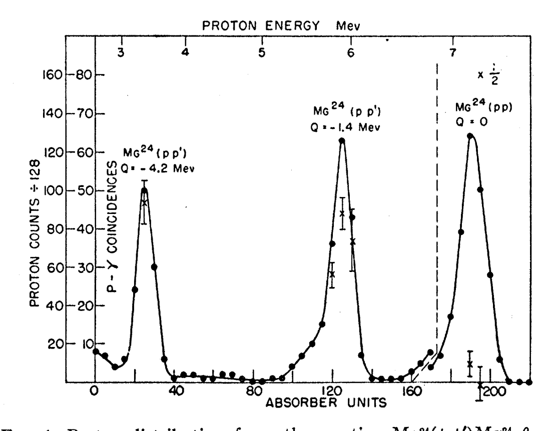

FIG. 1. Proton distribution from the reaction $Mg^{24}(p,p')Mg^{24}$ $\theta_p = 90°$ shown by solid circles and lines. The $p-\gamma$ coincidences under each peak taken with the gamma-counter at $\theta_\gamma = -90°$ are indicated with crosses.