X. TRANSPORT PHENOMENA IN SOLIDS

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RESEARCH OBJECTIVES AND SUMMARY OF RESEARCH

JSEP

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Our experimental work has centered on the study of surface thermal resistance, or Kapitza resistance, at liquid helium temperatures. We have been studying the time behavior of the temperature of a block of insulating crystal which is disturbed, by a heat pulse, from equilibrium with a thermal reservoir. The time decay of the temperature of the block to equilibrium can be interpreted to yield a value for the surface thermal conductance. The transient temperature of the block can be measured, even in the presence of slow drifts in the temperature of the reservoir. To check these data we also measure the influence of the thermal impedance of the block on the electrical impedance of a tiny bolometer that has been evaporated on the block to monitor the temperature of the block. The frequency dependence of the electrical impedance of the bolometer varies because of the frequency dependence of the thermal impedance of the block, which in turn depends on the boundary thermal conductance of the block.

Once a thorough understanding of the thermal properties of the block has been established, other materials (metals, for example) can be studied by evaporating a film on the block, or otherwise establishing thermal contact between the metal and the block. The perturbation of the thermal properties of the block produced by the foreign material then gives information about the thermal properties of the foreign material.

We have finished preliminary measurements on quartz, sapphire, and germanium. On all of these materials the thermal impulse response of the block temperature determined with a superconducting bolometer has been measured and partially analyzed. Impedance studies have been completed for sapphire and quartz. These data precipitated a large theoretical effort to develop a new model for the boundary thermal conductance. This was necessary, since the decay of temperature of the blocks proved not to be a single exponential. Correspondingly, the thermal impedance varied over a decade rather than over an octave as would be expected for a simple exponential decay. We have had some initial success in explaining these results by using a two-thermal-reservoir model for the crystal; that is, a model in which two nearly uncoupled degrees of freedom carry the thermal energy. For example, these could be the longitudinal and transverse lattice mode branches. The thermal resistance at the boundary which we determine from this model is in agreement with the value determined by other methods.

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