

III. SOLID STATE PHYSICS

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RESEARCH OBJECTIVES

1. Soft X-ray Spectroscopy

The soft X-ray spectroscopy program has as its objective the experimental study of the structure of the conduction band of electrons in a series of metals, particularly the alkalis, alkaline earths, and some of the transition metals. The filled portion of such a band can be studied by observing the emission spectrum produced by transitions from this band to the nearest sharp levels below this band. In most metals this corresponds to an energy in the range of 15-250 ev (wavelengths in the range 50-900A), so that the technique of extreme ultraviolet vacuum spectroscopy is applied. The energy width of these bands usually lies in the range of 2-10 ev. Present effort is directed to the measurement of the copper and nickel bands in a series of copper-nickel alloys of various compositions. A more detailed description of the procedures will be found in the Quarterly Progress Report of January 15, 1954, page 9.

G. G. Harvey

2. Microwave Study of Semiconductors

One of the general aims of the research on microwave study of semiconductors is to apply the methods and general point of view of the microwave gaseous discharge work to those problems involving semiconductors wherever it seems profitable.

S. C. Brown

3. Elastic Constants of Single Crystals

The development of digital computers capable of making the numerical calculations and the availability of accurate low-temperature specific heats have lead to a revival of interest in the theory of lattice dynamics. The vibrational frequency spectrum and thermodynamic properties of several face-centered cubic metals have recently been computed by a Born-von Karman calculation based on interatomic force constants derived from the adiabatic elastic constants of a metal single crystal. Since the specific heat at low temperatures is most sensitive to the parameters of the lattice model employed, calculations based on the elastic constants at liquid helium temperatures are of the greatest interest.

The adiabatic elastic constants of a crystalline substance may be calculated from the velocities of propagation of ultrasonic waves along various crystallographic axes. Pulsing circuits have made available a convenient method for measuring these velocities. A short high-frequency pulse is applied to a piezoelectric crystal cemented to a known crystallographic face of the test sample. The elastic wave so generated travels the length of the sample, reflects from a parallel face, returns, and is partially reconverted into an electric pulse by the transmitting crystal. By knowing the sample length and measuring the time delay between successive echo pulses, the velocity is determined.

Measurements of elastic constants and calculations of the frequency spectrum are in progress on metal single crystals of the hexagonal close-packed system. Although this is a common crystal system, it represents greater calculative difficulties than the face-centered cubic case, since it is not centrosymmetric. A theoretical treatment has been completed for a central force model. Measurement of the five independent

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elastic constants is being carried out from 4.2°K to 300°K. Work is almost complete on magnesium, which is close to an ideally packed structure, and is under way on zinc, which is highly anisotropic.

C. W. Garland

4. Liquid Helium Research

Two experiments are currently under way in the low temperature laboratory. We hope soon to round out our previous measurements of the attenuation of sound in liquid helium below 1°K at 12 mc, as a function of pressure, by acquiring data also at 2 mc and 6 mc. A second project is being initiated to measure the velocity of pulsed sinusoidal waves of second sound in the temperature range from 1°K, where there is very little dispersion, down to approximately 0.3°K, where the dispersion is so great that second sound can no longer exist as a wave motion. The results of both of these experiments should help clarify the nature of the elementary relaxation processes which lead to the establishment of thermal equilibrium in liquid helium at these temperatures, and possibly explain the behavior of other properties of the liquid.

W. M. Whitney