

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 available sharp levels below this band. In most metals this corresponds to an energy in the range 15-250 eV (wavelengths in the range 50-900 Å), so that techniques of extreme ultraviolet vacuum spectroscopy need be applied. The energy widths of these bands usually lie in the range 2-10 eV.

In order to eliminate uncertainties concerning the contamination of the metals being studied, a new ultra-high vacuum spectrograph has been constructed. Upon proper bake-out it has attained pressures of 5×10^{-10} mm Hg. Thus it will be possible to deposit clean targets and investigate them for hours before contamination develops. A new dispersion system also has been incorporated in the apparatus. This consists of an atomic beam from which photoelectrons are ejected upon soft X-ray bombardment. The photoelectron energies are analyzed by means of a $3\pi/2$ electron spectrometer using an Allen electron multiplier as a detector. Since almost all previous soft X-ray data have been obtained with grating spectrometers, this device will offer an entirely new means for confirming old as well as for obtaining new data.

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2. Elastic and Thermal Properties of Solids

In recent years there has been a revival of interest in lattice vibrations and the theory of lattice dynamics. The dispersion curves, vibrational frequency spectrum, and the bulk thermodynamic properties of a crystalline material can be computed by a Born-von Kármán calculation based on interatomic force constants. The adiabatic elastic constants of a single crystal may be measured with high precision, and provide data for evaluating these force constants. Since many properties are more sensitive at low temperatures to the parameters of the force model employed, calculations based on the elastic constants at liquid-helium temperature are of great interest.

The elastic constants of a crystal may be computed from the velocities of ultrasonic waves propagated along various crystallographic axes. Pulsed-circuit techniques provide a convenient method for measuring such velocities. Low-temperature measurements are being carried out on metals, intermetallic compounds, and inorganic salts. Thus far, special emphasis has been given to studies of hexagonal close-packed metals, some of which are highly anisotropic.

In connection with calculations based on lattice-dynamical models, it is vital to have precise heat capacity data in the region below 20°K. Calorimetric work is being carried out in the region 1°K-20°K with liquid helium and liquid hydrogen used as refrigerants. This region is also of particular interest for studying magnetic transitions, electronic specific heats, the nature of surface contributions to C_v for high-area solids, and anisotropic lattice effects.

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