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RF Project 384

Report No. 18

Progress

REPORT

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THE OHIO STATE UNIVERSITY
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To OFFICE OF NAVAL RESEARCH

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MR GUY 606

On X-RAY SPECTROSCOPY

For the period September 1, 1953 to April 22, 1954

Submitted by Charles E. Shaw

Date April 23, 1954

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X-RAY SPECTROSCOPY

The cryostat for mounting on the spectrometer for the investigation of the structure of X-ray absorption edges as a function of temperature from room temperature to 1.4°K is finished and in operation. At the bottom of the liquid-helium reservoir is an extension which forms a small container through which the X-ray beam from the target inside the spectrometer passes. The small container is closed by two beryllium windows, each 0.002 inch thick and vacuum sealed with indium gaskets. The X-ray beam, then, enters one window, passes through one cm of liquid helium, which serves to keep the window cold and which is transparent to the X-rays, and leaves by the other window to be analyzed by the two-crystal spectrometer. The wavelength range selected includes the absorption edge of any material deposited upon the cold beryllium window.

The problem under investigation at present is the structure of the K absorption edge of argon in both gaseous and solid states. The density-of-states curve in the gas is composed of the optical levels, which terminate in the continuum. The separate optical levels appear in the absorption curve as absorption lines. Previous results on argon gas have been corroborated by placing gaseous argon inside the small container mentioned above and examining the spectral distribution of radiation transmitted in the region of the K-absorption limit.

A uniform solid argon film of the correct thickness was obtained in the following way: The inside container, with its small absorption chamber, was filled with liquid helium. Argon gas was slowly admitted

into the spectrometer through a tube which ended near and was pointed at the outside of the cold beryllium window of the absorption chamber. The gas froze into a thin, uniform film, whose thickness was monitored by the absorption of X-rays in the film. When the optimum thickness was obtained, the argon was shut off, after which the spectral structure in the neighborhood of the absorption edge was examined. The results, though still preliminary, are definitive. Structure in the spectrum of the gas, the so-called Kossel structure, extends approximately 4 ev from the initial rise in absorption. In the solid, the absorption lines resulting from transitions to outer optical levels can no longer be distinguished, but instead there is wide but pronounced structure as far as about 30 ev from the edge. The initial rise in absorption, however, is equally rapid in the two cases, about the same in intensity and very little, if any, different in position. Precise measurements on this structure are under way. One possibility for the explanation of the structure is that it is a very intense Krong structure. That the Krong structure could be so intense might be expected from the nature of the wave functions in a crystal of a rare gas. These experiments make it certain, however, that the atom in the crystal excited in the K shell in the process of absorption does not act as an isolated impurity atom in the sense that the ejected electron comes to rest in hydrogen-like orbits "bound" to the excited atom. In other words, the ejected electron appears to be ejected into crystal states and not atomic states.

This is the first direct demonstration of the effect of the cry. lattice structure on the absorption edge of an element. A paper

is to be read at the Washington meeting of the American Physical Society, April 30, 1954, on this material by J. A. Soules and C. H. Shaw.

When argon is finished, it is proposed to examine Krypton in the same manner.

A technical report is being prepared on modifications made to the spectrometer since the last report on the instrument, on the construction of the cryostat and on the results of these experiments. This material will be part of the Ph.D. dissertation of J. A. Soules.

Investigator C. H. Shaw Date Apr 28, 1954

Supervisor do Date _____

For The Ohio State University Research Foundation

Executive Director Chas. C. Woodcock Date 4/8/54