LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Secondary Absorption and Fine Structure of X-Rays as Observed with a Double Crystal Spectrometer

Several observers have noted, in the case of solids and polyatomic gases, a secondary absorption or fine structure extending for some hundreds of volts on the short wave-length side of x-ray absorption edges in addition to the well-known fine structure in the edge itself. The results of experiments on this fine structure are in good agreement with Kronig's[1] theory of forbidden and permitted zones or energy levels in the crystal lattice. According to Kronig's theory, electrons in an atom of the crystal can not absorb quanta of certain discrete energy values if the initial impulse given to the electron is parallel to a crystal axis. On this basis the maxima and minima of the secondary absorption should be more pronounced when the electric vector of the incident x-rays is parallel to a crystal axis than when it is in some other direction or oriented at random. It is therefore important to test whether or not the secondary absorption is dependent on the degree of polarization of the incident x-rays and on the orientation of the electric vector with respect to the crystal axes of the absorbing screen.

The double crystal spectrometer with its high resolving power should be well adapted for this purpose if a combination of crystals can be found such that the first crystal can act both as monochromator and polarizer for wavelengths close to an absorption edge of one of the elements in the second crystal. Lindsay[2] has obtained secondary fine structure using one crystal for the double purpose of grating and absorber. Most of the data on secondary absorption have been obtained by the photographic method with a single crystal spectrometer, though Davis[3] and Hull[4] have obtained the fine structure in the main edge itself with a double crystal ionization spectrometer. It is therefore important to have the existence of the secondary absorption confirmed by the latter method. It so happens that the third order glancing angle with the (110) planes of calcite is approximately 45° for the wavelength of the K-absorption edge of bromine, thus giving complete polarization, while for second order reflection the polarization is some 75 percent.

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[1] R. de L. Kronig, Zeits. f. Physik **70**, 317 (1931); **75**, 191 (1932).

[2] G. A. Lindsay, Zeits. f. Physik **71**, 735 (1931).

[3] B. Davis and H. Purks, Phys. Rev. **32**, 336 (1928).

[4] H. L. Hull, Phys. Rev. **40**, 676 (1932).

One of us (Stephenson) is now engaged in experiments with a double crystal ionization spectrometer to test the effect of polarization on secondary absorption. The first reflection is from the (110) planes of calcite and the second from the cleavage planes of an artificial KBr crystal kindly sent us by Professor G. A. Lindsay of the University of Michigan. Because of the small intensity in the third order, the results so far have been obtained with the first crystal reflecting in the second order and the second crystal in the first, with a cube edge perpendicular to the
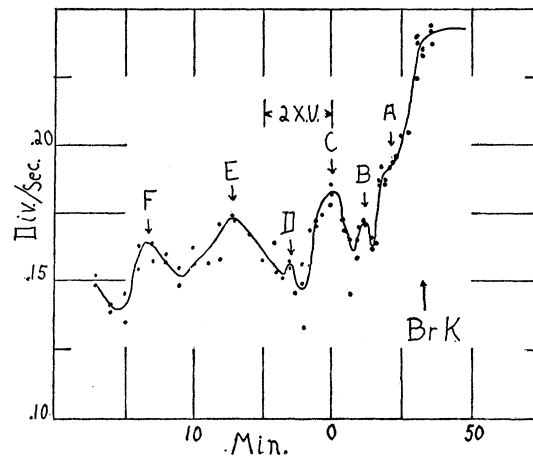

FIG. 1.

common plane of incidence. As can be seen from the accompanying curve, preliminary results show a pronounced secondary fine structure on the short wave-length side of the bromine K-edge similar to that obtained photographically by others. This curve is a composite curve containing points from several different runs in the (2, 1) position. The scattering of the points is due chiefly to three causes: (1) variation of electrometer sensitivity from day to day for which correction is difficult, (2) temperature changes between runs, (3) the smallness of the current measured, being of the same order as that due to a single alpha-particle. The uncertainty of any one electrometer reading is quite high, being sometimes nearly ten percent of the mean. Several readings are

averaged for each point on a curve and the curves are repeated several times. All the points are not given in this composite curve, but those given are representative.

The secondary absorption minimum C has been measured four times in the (2, 1) position and twice in the (2, −1) position; E and F have been measured twice in the (2, 1) position. The peak D may be due to crystal imperfections. The fine structure in the main edge at A is quite definite. The data so far obtained are insufficient

to establish the effect of polarization of the x-rays on the fine-structure, but they do confirm the results obtained by others photographically. Complete details of the experiment will appear at a later date.

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        March, 1933.

Potential Energy of Diatomic Molecules

Recently, in a paper by Ikehara and the present writer,[1] calculated results were presented giving the first-order $^1\Sigma$ energy curves for molecules consisting of two identical atoms, each with an outer s-electron, for various values of the effective principal quantum number. The $^3\Sigma$ energy curves were not given there although enough data were given so that they could be constructed. If one determines the $^3\Sigma$ curves one finds that for $n \leq 4$ they are of the usual form corresponding to a repulsive force. For $n = 5$, the curve has a minimum, and if one extrapolates to $n = 6$ (which can be done fairly accurately by extrapolating the Coulomb and exchange energy curves expressed as Morse[2] functions) one finds that in this case the minimum is below the asymptotic value at infinity, corresponding to the possibility of existence of a stable molecule. This effect is due to the rapid decrease in the importance of the exchange energy with increasing n. In Fig. 1 these curves are presented together with the $^1\Sigma$ curve for $n = 6$.

The $^3\Sigma$ curves in the diagram are not particularly important in themselves since the corresponding molecules could hardly be obtained under ordinary conditions. However, they are of interest in showing that the first-order perturbation method may sometimes lead to energy curves of the "radioactive decay" type, i.e., having a maximum beyond the minimum. It is quite likely that
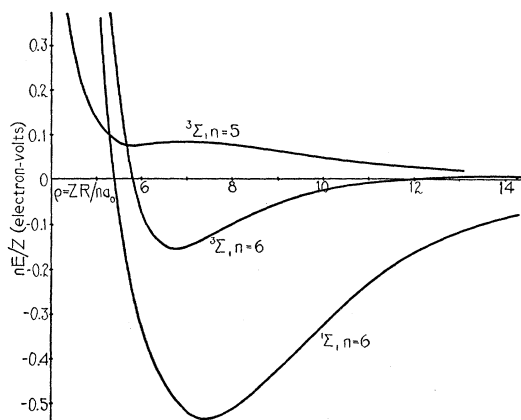

Fig. 1. Interaction energy curves.

for certain electronic levels, molecular energy curves similar to those discussed here may occur for smaller values of n, and hence with more pronounced maxima; the minima might be either above or below the axis. Such curves may be of importance in various types of predissociation, even if no rotation is present.

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    National Research Fellow
University of Michigan,
    March 30, 1933.

[1] Rosen and Ikehara, Phys. Rev. 43, 5 (1933).
[2] Morse, Phys. Rev. 34, 57 (1929).

On the Permeability of Iron at Ultra-Radio Frequencies

Recently there was published an interesting article by Hoag and Jones[1] who have worked out a method for exactly measuring the self-induction of wires in oscillating fields of wave-lengths between 22 and 64 cm. By this method they determined the self-induction of iron wire, calculated the permeability μ_n, and compared it with my values of permeability μ_k, previously calculated[2] from the resistance of wires at a frequency of the same order. As was the case for my values of μ_k Hoag and Jones find

[1] J. Barton Hoag and Haydn Jones, Phys. Rev. 42, 571 (1932).
[2] W. Arkadiew, Phys. Zeits. 14, 561 (1913); Ann. d. Physik 58, 105 (1919); Zeits. f. Physik 28, 11 (1924).

that the permeability μ_n calculated by them greatly diminishes at shorter wave-lengths. On the other hand, their values of permeability are appreciably lower than mine. This can be explained in the following manner. The essential difference between μ_k and μ_n appears in the following equations:

$$\mu_k = (\mu^2 + \rho'^2)^{\frac{1}{2}} + \rho' \qquad \mu_n = (\mu^2 + \rho'^2)^{\frac{1}{2}} - \rho',$$

where ρ', an essentially positive coefficient, together with the magnetic permeability μ serves to define the magnetic induction B. B is retarded with respect to the magnetic field H through the angle $\delta = \text{arctg } \rho'/\mu$:

$$B = \mu H_0 \cos (2\pi t/T) + \rho' H_0 \sin (2\pi t/T),$$