These experiments indicate that, if we look at X-radiation from the point of view of the emission of radiation quanta, having a certain amount of energy and momentum, we must assume that the momentum and energy are transferred not to single electrons but to atoms and groups of atoms, substantially as represented in a theory recently published[5] on the transfer of radiation momentum to matter in quanta.

[1] NATIONAL RESEARCH FELLOWS.

[2] THESE PROCEEDINGS, 9, 413; 9, 419 (1923); 10, 41; 10, 92; 10, 148; 10, 191 (1924).

[3] Compton and Woo, THESE PROOCEDINGS, 10, 271 (1924); Ross, THESE PROCEEDINGS, July, 1924; Becker, THESE PROCEEDINGS, August, 1924.

[4] *J. Optical Soc. Am. & Rev. Sci. Insts.*, **8**, 681 (1924).

[5] THESE PROCEEDINGS, 9, 158 (1923).

FURTHER EXPERIMENTS ON THE REFRACTION OF X-RAYS IN PYRITES

BY BERGEN DAVIS AND ROBERT VON NARDROFF

PHOENIX PHYSICAL LABORATORY OF COLUMBIA UNIVERSITY

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This is a report of further experiments on the refraction of X-rays in pyrites. The previously reported experiments (*Proc. Nat. Acad. Sci.*, **10**, No. 2, Feb., 1924) were made with the characteristic K radiation from molybdenum, the present experiments were made with the K characteristic radiation from copper. The method used is that of the reflecting the rays from a crystal surface ground to an angle φ to the reflecting planes. This method is described in the previous report.

The refractive effect depends very much on the frequency of the incident radiation. In general, it increases as the square of the wave-length. The longer wave-length radiation was used to test the applicability to X-ray phenomena of the Lorentz dispersion formula:

$$\delta = \frac{e^2}{2\pi m}\left[\frac{n_1}{\nu^2 - \nu_1^2} + \frac{n_2}{\nu^2 - \nu_2^2} + etc\right],$$

where n_1, n_2, etc., are the number of electrons per unit volume having the resonance frequencies ν_1, ν_2, etc. In the above expression $\delta = 1 - \mu$ where μ is the index of refraction.

In the case of the refraction of the copper K characteristic in pyrites, the critical absorption frequencies of iron and sulphur are sufficiently close to the incident frequency to increase the refractive effect and to show a marked dispersive effect.

In order to compare the Lorentz dispersion formula with the experimental results it was expressed in the following form:

$$\delta = \frac{e^2N}{2\pi m}\left[\frac{K_{Fe}}{\nu^2 - \nu_{Fe}^2} + \frac{K_s}{\nu^2 - \nu_s^2} + \frac{(Z_{Fe} - K_{Fe}) + 2(Z_s - K_s)}{\nu^2}\right],$$

where N = the number of FeS_2 molecules per cc.

Z = the Atomic Number.

K_{Fe} and K_s = the number of electrons in K ring of each iron and each sulphur atom.

ν_{Fe} and ν_s are the K critical absorption frequencies of iron and sulphur.

The L M, etc., absorption frequencies are small compared to that of the incident radiation and may be neglected.

The experiments were carried out with an optically calibrated ionization spectrometer. The angles measured are angles of setting of the crystal. No vernier readings are made. All readings are on a calibrated tangent worm and hand-wheel.

The refractive bending of the beam of X-rays on passing through the crystal surface is greatly increased by grinding the surface to an angle to the planes. For example, in the case of copper $K\alpha$ radiation incident on a pyrites crystal, the bending is 12″ arc for case when crystal surface corresponds to crystal planes. When, however, the surface is ground to an angle of approximately 15° to the crystal planes, the bending of the beam is 210″ arc.

The experimental results are given in the last column of the table. This table also shows the calculated values of δ for $K = 0, K = 1, K = 2, K = 3$. That is, one, two or three electrons in the K ring of an atom. In every case the remaining electrons are assigned to the outer rings. If $K = 0$ the formula reduces to:

$$\delta = \frac{e^2}{2\pi m}\frac{n}{\nu^2},$$

which applies to the case of a cloud of electrons without resonance frequencies.

The values of the K critical absorption wave-lengths for iron and sulphur used in the calculations were 1.74 $A°$ and 5.023 $A°$, respectively.

RADIATION	λ	$\delta \times 10^6$ (CALCULATED) K = 0	K = 1	K = 2	K = 3	$\delta \times 10^6$ OBSERVED
MOKα_1	.7077	3.29		3.31		3.35 ± .20
MOKβ_1	.6310	2.62		2.64		2.87 ± .20
CuKα_1	1.537	15.58	16.58	17.6	18.61	17.6 ± .5
CuKβ_1	1.389	12.69	13.12	13.53	13.95	13.2 ± .4

In the case of the Cu $K\alpha_1$ radiation the calculated values for various values of K differ sufficiently to permit of experimental comparison. The agreement is best for two electrons in the K ring. If future experiments completely establish the validity of the Lorentz dispersion formula in its application to X-ray phenomena, then this furnishes a means of measuring the number of electrons in the K ring of atoms. It is hoped to extend the method to measurements of the number of electrons in the L ring as well.

These results, together with those previously reported on the refraction of X-rays in calcite (Davis and Hatley, *Proc. Am. Phys. Soc., Physic Rev.*, Feb. 1924), indicate that the Lorentz dispersion formula may be valid in the case of X-radiation. This is of great interest and importance from the point of view of the quantum theory. The Lorentz theory is based on the principle of resonance. Each term grows large as the frequency of the incident radiation approaches that of any group of electrons in the atom. A quantum theory of dispersion must take account of the fact that at the critical absorption frequencies, the reactions of the electrons are similar to those of any other electro-mechanical system.

AN IMPROVED METHOD OF MEASURING THE SPECIFIC HEATS OF METALS AT HIGH TEMPERATURES

BY K. K. SMITH AND L. I. BOCKSTAHLER

DEPARTMENT OF PHYSICS, NORTHWESTERN UNIVERSITY

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Some time ago a method of using thermionic currents in the determination of the heat capacity of an incandescent filament was devised by one of us.[1] One strip of a double high frequency oscillograph carries the thermionic current emitted by the filament; the other strip, with a suitable resistance, is connected in series with the filament, or parallel with it. As the thermionic current changes by a considerable amount when the temperature of the filament changes slightly, the cyclic variations in temperature of a filament heated by an alternating current can easily be shown. In this case, the thermionic current is a direct current on which is superposed an alternating current whose frequency is twice the frequency of the heating current. Also the thermionic current reaches its maximum value after the heating current has passed through its maximum value. If the thermionic emission has been measured at a number of steady temperatures, it is possible to determine the amplitude of these cyclic variations in temperature, as well as the lag from a study of the photographic record made by the oscillograph.