[1] For description of polymorphism in Miastor see Harris, R. G., "Occurrence, Life-cycle, and Maintenance under Artificial Conditions of Miastor." *Psyche*, **30**, pp. 79 (1923).

[2] Springer, Fritz. "Polymorphismus bei den Larven von *Miastor metraloas*." *Zool. Jahrb. Abth. J. Anst.*, **40**, p. 57 (1917).

[3] At the Laboratoire de l'évolution des êtres organisés, Paris. Prof. M. Caullery, Director.

[4] Acknowledgment is made to Dr. C. B. Davenport for facilities and suggestions offered in connection with this work at the Dept. of Genetics of the Carnegie Institution of Washington at Cold Spring Harbor.

[5] Oligarces, closely related to Miastor and having a similar life-cycle. A description of the species will appear shortly.

[6] Williston, S. W., *North American Diptera*, 3rd. Edit., p. 120.

[7] Parshley, H. M., *The Canadian Entomologist*, **55**, pp. 69–70.

THE WAVE-LENGTHS OF SECONDARY X-RAYS

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Some years ago, researches on the spectra of secondary X-rays were begun in our laboratory. The object of these researches was to measure accurately with a spectrometer the fluorescent spectra of chemical elements, the idea being: (*a*) to find out whether any appreciable difference in wave-length exists between the lines in the fluorescent spectra and those in the emission spectra obtained in the usual way with the elements in the target of the X-ray tube, and (*b*) to determine the wave-lengths of the lines in the spectra of the elements, which have not yet been recorded.

Previously Duane and Shimizu[1] had measured by means of a spectrometer the wave-lengths of fluorescent X-rays belonging to the α and β lines in the L series of lead.

Recently the work has been taken up again with greatly improved apparatus. During the course of these researches, phenomena appeared from which the wave-lengths of the scattered radiation coming from the secondary radiator can be determined, and the object of this preliminary note is partly to present data which bear upon the important question under discussion at the present time, namely, whether any differences exist between the wave-lengths of scattered X-rays and those of the primary rays that produce them.

In our experiments we used a Coolidge tube with a tungsten target. A current of about two milliamperes passed through the tube coming from a generating plant (previously described) consisting of transformers, kenotrons and electrical condensers so arranged as to produce a constant non-fluctuating voltage of 80,000 to 90,000 volts. This voltage suffices to produce fairly intense lines in the K series of the tungsten target, which have wave-lengths in the neighborhood of .2 ångström.

Figure 1 represents the arrangement of the apparatus. The primary X-rays come from the target of the X-ray tube and fall upon the secondary radiator which lies opposite a slit, 1, between lead blocks. Some of the secondary rays from the radiator pass through slit 1, a hole in the brick wall and a second slit, 2. A large lead screen, $^3/_8$ inch thick, fastened against the wall, as indicated, gives additional protection to the X-ray spectrometer which lies in a room adjoining that containing the X-ray tube and the generating plant. The rays from the secondary radiator, after passing through slits 1 and 2, strike the calcite crystal of the spectrometer which reflects some of them into the ionization chamber. A sensitive quadrant electrometer measures the ionization current in the usual way. A thick sheet of lead lies between the tube and the first slit $S1$ and prevents the primary X-rays from striking the sides of this slit. We found by experiments that this protection was very important, for, without it, our spectrometer readings indicated radiation that did not come from the radiator itself, and that might have been interpreted as evidence of scattered radiation from the radiator having a wave-length differing from its true value.

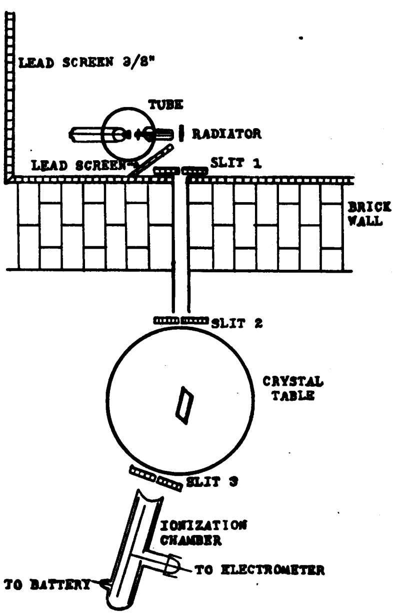

FIGURE 1

The curves in figures 2 and 3 represent the ionization currents as functions of the positions of the crystal, the ionization chamber always being placed in such a position as to receive the reflected beam. In the experiments represented by figure 2 the secondary radiator consisted of a barium salt (barium chloride) and in those represented by figure 3 the secondary radiator consisted of a lanthanum salt (lanthanum oxide). The curves correspond to readings taken on both sides of the zero line of the spectrometer, and the angle θ, to be substituted in the Bragg equation for the wave-length, λ, namely $n\lambda = 2d \sin \theta$, is $^1/_2$ the angle measured from a point on the curve to the corresponding point on the curve on the other side of the zero line.

A number of peaks occur on the curves. Some of the peaks (as indicated in the figures) correspond to the Kα and Kβ lines of the tungsten target reflected in the spectra of the first and second orders. The other peaks correspond to the K lines of the chemical elements in the secondary radiator, barium or lanthanum as the case may be.

Table 1 contains the readings of the vernier that determine the angular positions of the crystal corresponding to the various peaks, beginning with the peaks nearest the zero line of the spectrometer.

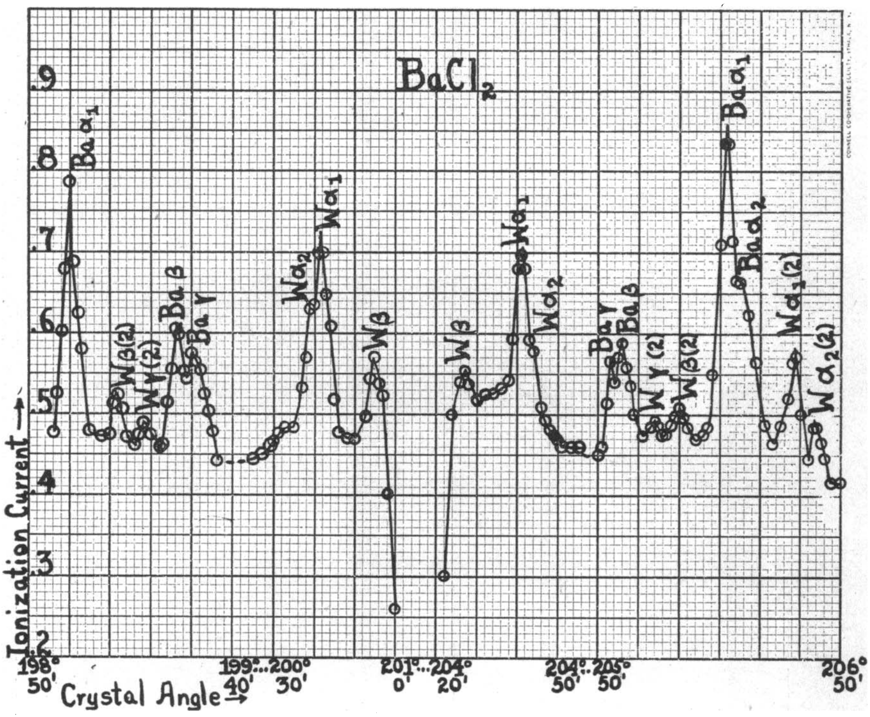

FIGURE 2

Table 2 contains the wave-lengths corresponding to the various peaks as calculated from the Bragg equation. The wave-lengths of the scattered rays were calculated from the second order spectra, where the α_1 line appears completely separated from the α_2 and the β from the γ. The numbers in parentheses are the recorded wave-lengths of the various lines in the primary spectra obtained with the corresponding chemical elements in the target of the X-ray tube. The wave-lengths for tungsten were measured in our laboratory,[2] and those for the other chemical elements in Siegbahn's.[2] The table also contains the wave-lengths corresponding to peaks determined in experiments similar to those for barium and lan-

TABLE I

ANGULAR POSITIONS OF CRYSTAL CORRESPONDING TO VARIOUS PEAKS

CHEMICAL ELEMENT	SPECTRUM LINE	SPECTRUM ORDER	BARIUM		CHEMICAL ELEMENT	SPECTRUM LINE	SPECTRUM ORDER	LANTHANUM	
			RIGHT	LEFT				RIGHT	LEFT
Tungsten	β	1	204°26′	200°55′	Tungsten	β	1	204°25′	200°56′
Tungsten	α_1	1	204°40′½	200°41′½	Tungsten	α_1	1	204°39′	200°42′
Tungsten	α_2	1	204°43′¼	200°39′	Tungsten	α_2	1	204°41′½	200°39′
Barium	γ	1	205°52′	199°30′½	Lanthanum	γ	1	205°45′	199°42′
Barium	β	1	205°56′	199°26′½	Lanthanum	β	1	205°49′	199°39′
Tungsten	γ	2	206° 4′	199°18′	Tungsten	γ	2	206° 5′	199°17′½
Tungsten	β	2	206°10′	199°12′	Tungsten	β	2	206°11′	199°12′
Barium	α_1	1	206°21′½	199°00′	Lanthanum	α_1	1	206°13′¼	199° 9′
Barium	α_2	1	206°25′		Lanthanum	α_2	1	206°15′½	199° 7′½
Tungsten	α_1	2	206°38′½		Tungsten	α_1	2	206°39′¼	198°43′¼
Tungsten	α_2	2	206°43′½		Tungsten	α_2	2	206°44′¼	198°38′¼

TABLE II

WAVE-LENGTHS CALCULATED FROM POSITIONS OF PEAKS ON IONIZATION CURVES

SECONDARY RADIATORS	FLUORESCENT WAVE-LENGTHS				SCATTERED WAVE-LENGTHS			
	α_2	α_1	β	γ	α_2		β	γ
Potassium Iodide	.4417	.4368	.3878	.3818	.2130	.2086	.1842	.1789
	(.——)	(.437)	(.388)	(.—)				
Barium Chloride	.3943	.3886	.3429	.3359	.2134	.2090	.1840	.1787
	(.393)	(>.388)	(.343)	(.—)				
Lanthanum Oxide	.3767	.3735	.3257	.3196	.2140	.2086	.1844	.1794
	(.376)	(.372)	(.329)	(.—)				
Praseodymium	.3486	.3433	.3011	.2958	.2130	.2086	.1840	.1796
	(.347)	(.342)	(.301)	(.—)				
Neodymium Carbonate	.3345	.3301	.2923	.2871				
					PRIMARY WAVE-LENGTHS			
	(.—)	(.330)	(.292)	(.—)	(.2134)	(.2086)	(.1842)	(.1790)

thanum in which the secondary radiators consisted of potassium iodide, neodymium carbonate and praseodymium carbonate, respectively.

It appears from the table that the wave-lengths of the fluorescent rays coming from the chemical elements employed as secondary radiators do not differ from those obtained when the elements are used in a target by more than a small fraction of 1%, which is no larger than the errors of measurement in experiments of this kind. In other words, the wave-lengths of lines in the secondary fluorescent spectrum of a chemical element equal, within the experimental errors, the wave-lengths of the same lines excited by the bombardment of the same chemical element by electrons in an X-ray tube. This agrees with the modern theory of X-radiation.

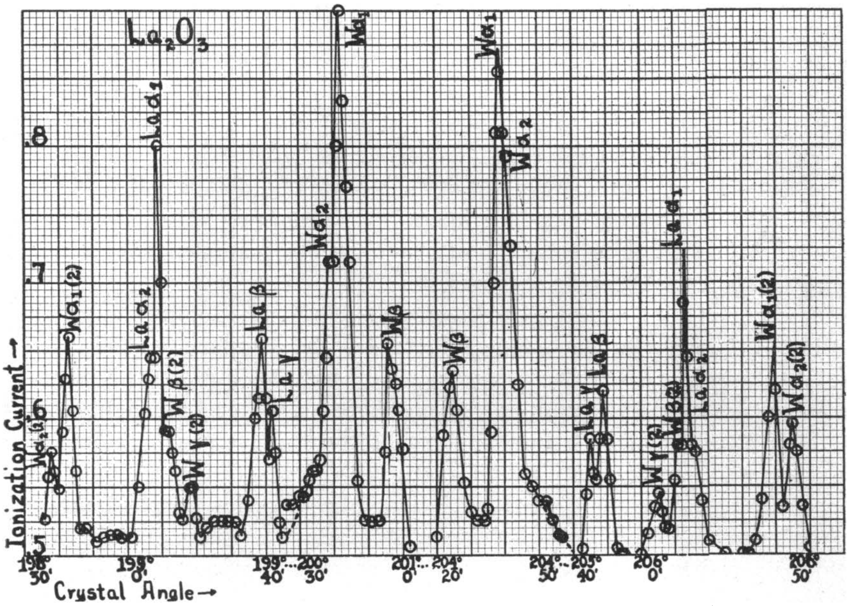

FIGURE 3

The frequencies of the fluorescent lines, to a remarkable degree of accuracy, equal the differences between critical absorption frequencies (where these have been recorded), as they should according to the combination principle; and the square roots of these frequencies are nearly linear functions of the atomic numbers of the chemical elements.

An examination of the heights of the peaks shows that the relative intensities of the lines in the K series of fluorescent rays are substantially the same as the relative intensities recorded for the primary rays from tungsten, molybdenum and rhodium.

Further, the peaks representing scattered X-rays from the K series lines of the tungsten target correspond to wave-lengths that are precisely equal to those measured in the primary radiation coming directly from the tungsten target itself. In other words, secondary radiation contains a large number of scattered rays of precisely the same wave-lengths as those of the primary rays.

We have not been able to detect the presence of any rays in the secondary radiation having wave-lengths a certain fraction of an ångström longer than those of the primary rays, as an interesting theory recently published by A. H. Compton[3] demands. According to this theory, the scattered rays at right angles to the primary beam ought to have wave-lengths .024 ångström longer than those of the primary rays and this difference should be independent of the wave-lengths of the primary, exciting rays. The wave-length shift of .024 ångström corresponds to a difference in the setting of our reflecting crystal of about 13′ or 14′. There are no peaks on our curves 13′ or so further away from the zero line than the tall peaks corresponding exactly with the wave-lengths of the strong α lines in the K series of the tungsten target. Undoubtedly, there are some rays in the secondary radiation having wave-lengths longer than those of the primary rays, but the amount of this radiation having the definite wave-lengths shift .024 appears from our experiments to be inappreciable as compared with the amount of scattered radiation having wave-lengths precisely equal to those of the primary rays.

In some very important experiments (*l. c.*), A. H. Compton showed a definite difference in wave-length between the primary and scattered radiation when he used the K series lines of molybdenum as the primary radiation. The molybdenum lines have wave-lengths in the neighborhood of .7 ångström, i.e., $3^1/_2$ times as long as the tungsten lines. In these experiments he employed carbon as the secondary radiator. We have, therefore, repeated our experiments using the K series lines of tungsten as the primary radiation with carbon, aluminium, sulphur and copper as secondary radiators. These experiments will be described and the results discussed in another note.

[1] *Physic Rev., Ithaca,* Nov. 1919, 391.

[2] See *Bull. Natl. Res. Council, Washington,* Nov. 1920.

[3] *Bull. Natl. Res. Council,* Oct. 1922, p. 16; *Physic. Rev.,* May 1923, p. 483 and June 1923, p. 715.