their minima, we see at once that the most probable transitions are going to give nuclear separations which will not result in dissociation. This is in perfect accord with experiment.

Until we know more of the excited states of the H_2^+ ion we cannot proceed with explanations of the effects that still faster electrons may produce.

[1] Winans and Stueckelberg, these PROCEEDINGS, **14**, 867, 1928.

[2] We are assuming the weak ionization sometimes reported at about 11 volts, is due to an impurity.

[3] Compton and Mohler, *Critical Potentials*, p. 115.

[4] Hughes and Skellet, *Physic. Rev.*, **30**, pp. 11–35, 1927.

[5] Glockler, Baxter and Dalton, *J. Am. Chem. Soc.*, **49**, pp. 58–65, 1927.

[6] Burrau, *Kgl. Danske Vid. Selskal. Math-fys. Med.*, **7**, 14, 1927.

[7] Hopfield, *Physic. Rev.*, **31**, p. 918, 1928.

THE STRUCTURE OF THE COMPTON SHIFTED LINE

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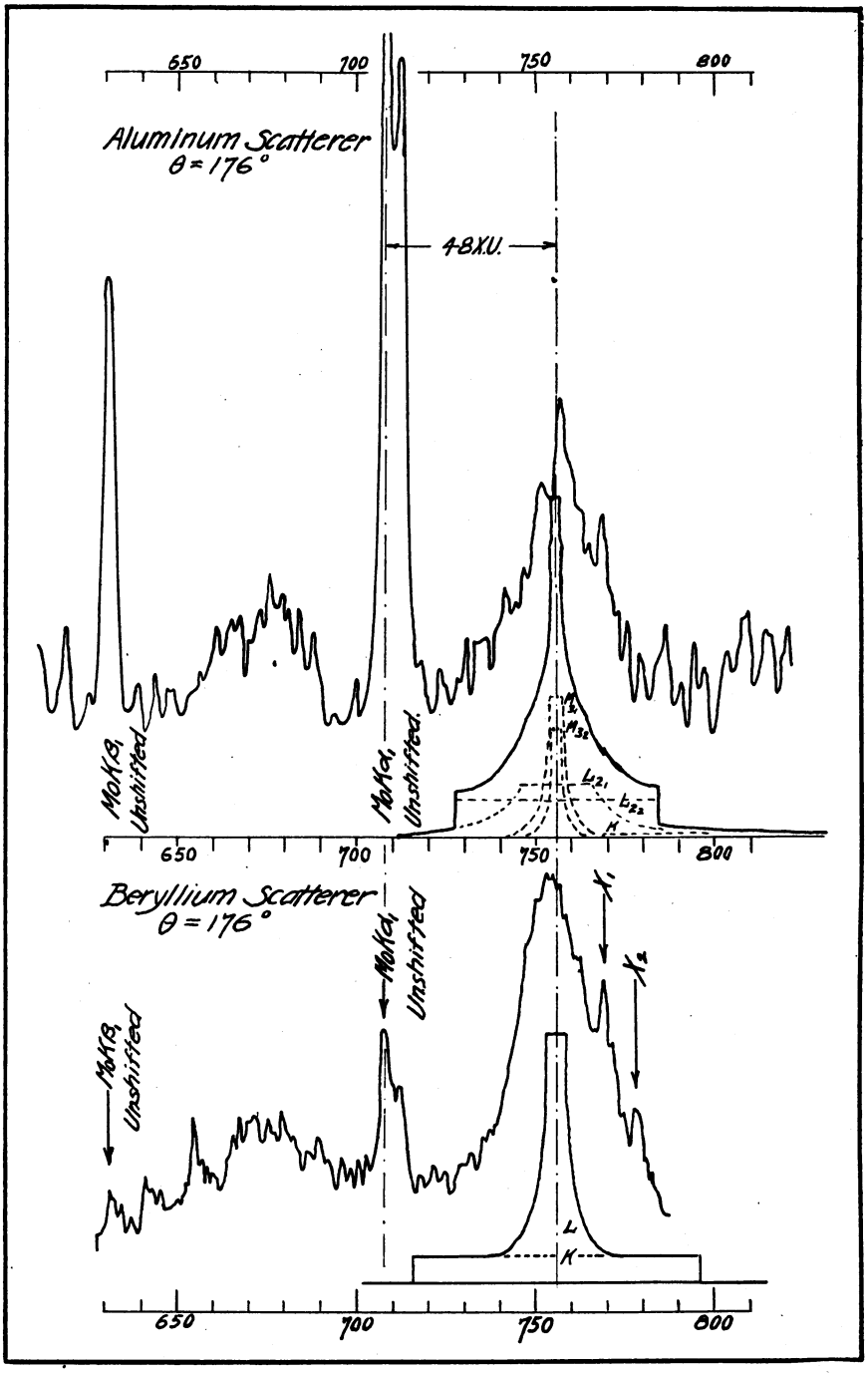
According to Wentzel's[1] wave mechanical theory of modified x-ray scattering and also according to Jauncey's[2] classical-quantum theory of the same effect (though not explicitly so stated by Jauncey), the modified scattered x-radiation is regarded as due to many Smekal transitions[3] in each of which the initial state of the electron is a discrete negative energy level and the final state is one of the continuum of positive energy levels. In both of these theories the shifted "line" is predicted as a diffuse band, the diffuseness being due to the momenta of bound electrons in the dynamic atom model. Indeed, the natural breadth of the Compton modified line can be regarded as a Doppler broadening for x-rays scattered by moving electrons in much the same way as the temperature broadening is regarded in the case of optical spectra. The broadening of the Compton line is the most direct evidence for a dynamic atom model yet found. The structure of the line can be interpreted in such a way as to give the probability distribution of electron momenta in atoms. The breadth for circular orbits should be proportional to the effective atomic number of the scatterer.

In order to determine the natural structure of the Compton modified line it is necessary to first minimize an experimental cause for the breadth of the line which is ordinarily superposed upon the natural breadth so as to mask the latter. This cause is the unavoidable inhomogeneity of scattering angle. The x-radiation incident upon the scattering material

must be somewhat divergent, for the more divergent the cone of incident x-rays the more primary energy available for the very wasteful scattering process. The scattered x-rays must be sensibly parallel if they are to be analyzed spectroscopically by a crystal. Hence the unavoidable inhomogeneity of scattering angle. There results a corresponding inhomogeneity of shift since the shift is related to scattering angle by the formula $\lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta)$. A minimum inhomogeneity of shift due to inhomogeneity of scattering angle occurs when θ, the scattering angle is in the vicinity of 180° where the expression above has an analytic maximum. Scattering at 180° presents, moreover, the advantage of a maximum shift. Also the predicted natural breadth of line is a maximum for 180° scattering angle.

To facilitate scattering at this large angle and also to permit bringing the scattering material close to the source of primary x-rays so as to increase incident intensities and reduce the necessarily rather long exposure time, a special tube[4] was constructed containing the scattering material and the Seeman crystal spectrograph in a small box supported on the end of the standard Coolidge water-cooled molybdenum target. The primary radiation leaves the target at a small angle to its surface and the scattered radiation returns in a line parallel to that surface about a millimeter away. The scattering angles vary from 170° to 178°, a large proportion of scattering being at 176°. The increase in the natural line breadth should be less than 1 X.U. Great care was taken in designing the geometry of the box to avoid observing any radiation other than that coming from the scattering block. The analyzing crystal was a tiny piece of quartz (used for its heat-resisting properties). The resolution of the spectrograms is good as can be seen by the width of lines other than the Compton line. An analysis of some of the negatives with the microphotometer yielded the experimental curves shown. The theoretical curves were computed with the help of Jauncey's theory and reasonable assumptions as to electron-momentum distribution.

The correspondence between observed and calculated line structure for scattering by aluminum ($Z = 13$) is good. However, the experimentally found distribution for beryllium ($Z = 4$) is wider than theory predicts. Two faint but perfectly distinct lines also appear of wave-lengths 768 and 777 X.U. The shift of these lines is too great to account for them as Smekal transitions between discrete energy levels in beryllium. Neither have they yet been accounted for as characteristic fluorescence lines of any element whatever. The possibility of accounting for the extra breadth of the shifted line by double scattering considerations is now being investigated. The work is being continued both by the double crystal method of Bergen Davis[5] and by means of a special newly devised multiple crystal


650
700
750
800
Aluminum Scatterer
θ = 176°
48X.U.
MoKα Unshifted
MoKα Unshifted
L
M32
L21
L22
K
650
700
750
800
Beryllium Scatterer
θ = 176°
MoKα Unshifted
MoKα Unshifted
K1
K2
L
K
650
700
750
800

spectrograph having some of the advantages of the concave optical grating. The latter method permits the study of scattering at other angles than 180°, maintaining good homogeneity of scattering angle.

[1] G. Wentzel, *Zeits. Phys.*, **43**, 1–2, pp. 1–8, 1927; *Ibid.*, **43**, 11–12, pp. 779–787, 1927.

[2] J. E. M. Jauncey, *Phys. Rev.*, **25**, pp. 314–322, Mar., 1925; *Ibid.*, **25**, pp. 723–736, June, 1925.

[3] Smekal, *Naturwiss.*, **11**, pp. 873, 1923. *Zeits. Phys.*, **32**, pp. 241, 1925.

[4] J. W. DuMond, *Nature*, **116**, p. 937, Dec., 1925.

[5] Bergen Davis, *Proc. Nat. Acad. Sci,*, **13**, pp. 419, June, 1927. *Phys. Rev.*, pp. 331, Sept., 1928.

SOME MULTIPLETS OF DOUBLY IONIZED LEAD

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The most conspicuous lines in the spectrum of doubly ionized lead (Pb III) would be expected to arise from singlet and triplet terms as in the case of Hg I. In the normal state of the Pb^{++} ion the two valence electrons are presumably in 6*s* orbits giving rise to the lowest term $(6s6s)^1S_0$. Other important terms to be expected are $(6s6p)^3P_{0,1,2}$, $(6s6d)^3D_{1,2,3}$, $(6s6f)^3F_{2,3,4}$, $(6s7s)^3S_1$ and $(6p6p)^3\overline{P}_{0,1,2}$. The singlet terms are omitted as this communication deals only with combinations between triplet terms.

TABLE 1

TRIPLET SYSTEM OF PB III

	$(6s6p)^3P_0$		$(6s6p)^3P_1$		$(6s6p)^3P_2$
$(6p6p)^3\overline{P}_0$			1279.44 (15)		
			78159		
			7535		
$(6p6p)^3\overline{P}_1$	1114.99 (9)		1166.94 (15)		1406.57 (12)
	89687	3993	85694	14599	71095
			14734		14738
$(6p6p)^3\overline{P}_2$			995.75 (10)		1165.05 (15)
			100428	14595	85833
$(6s6d)^3D_1$	1030.44 (15)		1074.63 (15)		1274.56 (10)
	97046	3991	93055	14597	78458
			477		482
$(6s6d)^3D_2$			1069.15 (20)		1266.79 (15)
			93532	14592	78940
					1032
$(6s6d)^3D_3$					1250.43 (20)
					79972
$(6s7s)^3S_1$	1052.23 (7)		1098.39 (10)		1308.10 (15)
	95036	3994	91042	14595	76447