On a Mica X-Ray Spectrometer.

By

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A convenient x-ray spectrometer of bent mica was first devised by de Bloglie and Lindemann[1], and by Rohmann[2] simultaneously. The former workers[3] obtained an x-ray spectrum of the L series of platinum up to its sixth order by this instrument, and they showed that the grating constant d of mica was about 10×10^{-8}cm. Next, a quite different result was obtained by Gorton[4]. From the measurement on the spectrum of tungsten he concluded that the mica had four reflecting sets of planes parallel to the cleavage face, and that the four grating constants corresponding respectively to these four sets were in no simple rational relation to each other. Gorton's conclusion is inconceivable with our actual knowledge, and it was already pointed out by Siegbahn[5] that Gorton's result was based on a false assumption.

The measurement of the wave lengths of x-rays by previous experimenters with the bent mica x-ray spectrometer was not so accurate as with the other spectrometers. And as it seemed to the writer not to be valueless to test how accurately the wave length was determinable with this spectrometer, the author has undertaken essentially the same experiment as that of Gorton.

The spectrometer used is represented diagramatically in Fig. 1. B represents a lead box, and S the slit the width of which is

1 De Broglie and Lindemann, C. R., **158**, 944, (1914).
2 Rohmann, Phys. Z.S., **15**, 510, (1914).
3 De Broglie and Lindemann, j. de Phys., **4**, 265, (1914).
4 Gorton, Phys. R., **7**, 335, (1916).
5 Siegbahn, Phys. R., **8**, 320, (1916).

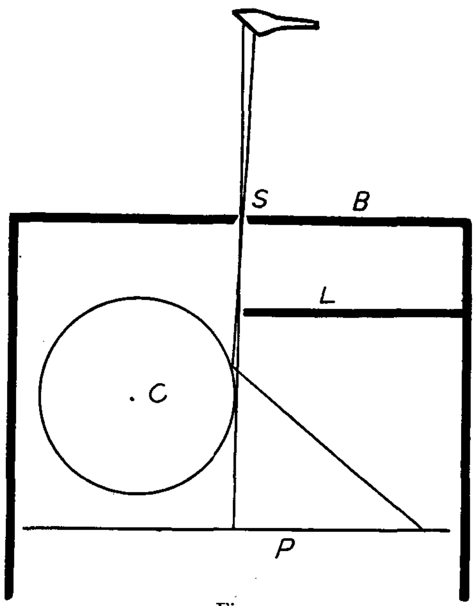

Fig. 1.

0.3 mm. C is a wooden cylinder of radius 36.39 mm., and on its surface a sheet of mica of a thickness of 0.07 mm. is just fastened. Consequently the radius of the cylindrical mica is 36.46 mm. This cylinder of mica is placed in such a position that the perpendicular from the slit S to the plane of the photographic plate P is exactly in the position of a tangent to the cylinder. A lead screen L is placed in a proper position to prevent the one half of photographic plate from being attacked by the direct rays from the x-ray tube. The mica to be used as the reflector was carefully examined, and a pretty good one free from deformation and other irregularities was selected.

A Coolidge x-ray tube having a tungsten anticathode was employed in the present experiment. The time of exposure was from one to three hours, using currents of the order of 4 milliamperes and the potential differences of from 40 to 70 kilovolts.

An example of the photographs obtained is reproduced in Fig. 3. The spectrum lines of the L series of tungsten are visible on the photograph up to the fifth order, those in the third and fifth order being superior in intensity to the others. Here it is to be noted that some faint lines which were visible on the original plate are absent in the reproduction.

The relation between the distance of a spectrum line from the zero position on the photographic plate and the glancing angle of the ray on the cleavage face of the mica crystal may be calculated simply in the following way:

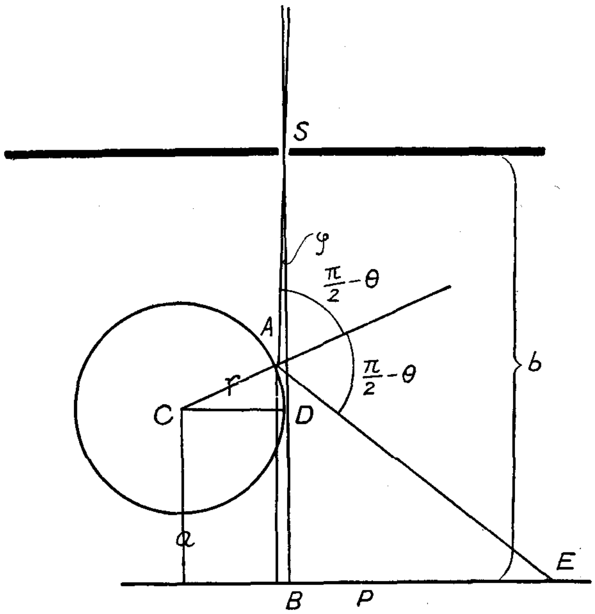

Fig. 2.

In Fig. 2, S is the slit through which the x-rays advance toward the photographic plate P. The path of the ray which is tangential to the cylindrical mica and perpendicular to the photographic plate is denoted by the straight line SB, and that of the ray which impinges on the mica at A and is reflected toward AE is represented by SA. Let φ be the angle ASB, and θ the glancing angle of the ray SA to the cleavage face of the mica at A, r the radius of the cylindrical mica, b the distance between the slit and the photographic plate P, and a the distance between the center of the cylinder C and the photographic plate P. Then the relation between φ and θ is given by the formula

$$\tan\varphi = \frac{r\{1-\cos(\theta-\varphi)\}}{b-a-r\sin(\theta-\varphi)}.$$

The values of r, a and b were 36.46 mm., 51.9 mm. and 156.7 mm. respectively in the present case. Making use of these values, the numerical value of φ corresponding to a given value of θ may be calculated by the method of successive approximation. Next let x be the distance between B and E, then the value of x corresponding to a given value of θ may be calculated by the formula

$$x = \{a + r \sin(\theta - \varphi)\} \tan(2\theta - \varphi) - r\{1 - \cos(\theta - \varphi)\}.$$

Thus the relation between the values of x and $\sin\theta$ being expressed by a curve, the value of $\sin\theta$ corresponding to a given value of x may be obtained immediately.

Here it must be noted that the zero position B on the photographic plate in Fig. 2, where the ray which was tangential to the cylindrical mica attacked the plate, was well defined in the original plate, as the shadow of the mica cast by the x ray, though it is not visible in the reproduction. This was very favorable and convenient for accurate determination of the zero position.

TABLE I.

d in A.U.

order		γ_3	γ_2	γ_1	β_2	β_3	β_1		β_4	α_1	α_2	mean value of d
1	$\sin\theta$			0.0553	0.0626		0.0644			0.0743		
	d											
2	$\sin\theta$			0.1107	0.1254	0.1272	0.1291		0.1309	0.1486		
	d			9.897	9.903	9.906	9.909		9.921	9.917		9.909
3	$\sin\theta$			0.1658	0.1881	0.1906	0.1937	0.1947	0.1965	0.2231	0.2246	
	d			9.911	9.903	9.916	9.906		9.915	9.908	9.914	9.910
4	$\sin\theta$			0.2213	0.2506		0.2581			0.2976		
	d				9.911		9.913			9.905		9.909
5	$\sin\theta$	0.2669	0.2684	0.2764	0.3132	0.3176	0.3224		0.3272	0.3718		
	d			9.910	9.912	9.921	9.919		9.921	9.907		9.915
mean value of d												9.911

TABLE II.

Wave lengths in A.U.

order	γ_3	γ_2	γ_1	β_2	β_3	β_1		β_4	α_1	α_2
1			1.096	1.241		1.277			1.473	
2			1.097_2	1.242_8	1.260_0	1.279_5		1.297_4	1.472_8	
3			1.095_2	1.242_8	1.259_5	1.279_9	1.286_3	1.298_4	1.474_2	1.484_0
4			1.096_5	1.241_9		1.279_0			1.474_8	
5	1.058	1.064	1.095_8	1.241_7	1.259_1	1.278_2		1.297_2	1.474_0	1.485_0
Mean	1.058	1.064	1.096_2	1.242_3	1.259_5	1.279_2	1.286_3	1.297_7	1.474_0	1.484_5
Siegbahn	1.05965	1.06584	1.09553	1.24191	1.26000	1.27917	1.2871	1.29874	1.47348	1.48452
Dershem	1.059	1.065	1.095	1.242	1.259	1.278	1.287	1.298	1.472	1.483

The results of the measurement are tabulated in the tables I and II. The grating constant d for the mica was calculated by the relation $2\,d \sin\theta = n\lambda$, by assigning proper values to n and λ corresponding to each observed value of $\sin\theta$. For the wave length λ, the values recently given by Siegbahn[1] for the L series of tungsten was employed. As may be seen from Table I, the value of the grating constant d determined from every line is in fair agreement with each other. The mean value of d calculated from those of the lines in all the orders from the second up to the fifth is 9.911 A.U., which is smaller by one per cent. than that given by de Broglie and Lindemann.

Next, taking the grating constant d of the mica as 9.911 A.U., the wave lengths of the lines observed were calculated reversely, and are given in Table II. The observed values are in fair agreement with those given by Siegbahn and Dershem,[2] and they differ only by small quantities less than 0.2 per cent from those given by the other observers.

In conclusion, the writer wishes to express his sincere thanks to Prof. T. Mizuno for the interest he has taken in the research.

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1 Siegbahn, Phil. Mag., **38**, 639, (1919).

2 Dershem, Phys. R., **11**, 471, (1918).

Fig. 3.