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Jadwiga Szmidt

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XVIII. *Note on the Excitation of γ Rays by β Rays.*
By JADWIGA SZMIDT (Petrograd).*

IT was shown by J. A. Gray† that the β rays from radium E falling on metallic radiators produce a certain amount of secondary radiation of a γ -ray type. The penetrating power of this secondary radiation was found to vary largely, being as a rule softer the lower the atomic weight of the radiator. A similar result holds when cathode particles fall on the radiator‡ or when X rays of suitable penetrating power fall on the radiator, exciting its characteristic radiation§. It was thought of interest to determine whether the secondary γ and X rays were identical by comparing their absorption in aluminium.

The particular arrangement originally used by Gray not being suitable for the purpose, the following method was adopted :—

The source R—radium D in equilibrium with its product radium E—was placed in a strong magnetic field and the

Fig. 1.

primary β rays therefore could not strike the metallic sheet under investigation, when the latter was placed at A (fig. 1). The metallic sheet absorbed the primary γ -radiation to a

* Communicated by Sir Ernest Rutherford, F.R.S.

† J. A. Gray, Proc. Roy. Soc., A, vol. lxxxv. p. 131 (1911).

‡ Beatty, Proc. Roy. Soc. A, vol. lxxxvii. p. 511 (1913).

§ Barkla and Sadler, Phil. Mag. vol. xvii. p. 739 (1909).

large extent, especially the softer constituent; absorbing aluminium-foils were placed between sheet and electroscope close to A, and an absorption curve obtained in the usual way. The electroscope E was of aluminium and contained methyl iodide*, since this gas is known to increase relatively the effects of the soft radiations. If now the metallic sheet is shifted to position B close to the source, a very large increase in ionization is noticed: this must be due to the excitation of secondary rays by the β particles, which now are allowed to strike the radiator; a simple geometrical consideration shows that it would be impossible to attribute more than a very small part of this secondary effect to primary γ -rays striking the radiator in position B under a larger solid angle than in position A. A second absorption curve was obtained with the radiator at B and the absorbing foils in the same position as before, that is at A. By comparing the two curves and subtracting the primary effect from the effect increased by secondary rays, we find the absorption curve for the purely excited radiation.

The advantages of this method are the following:—

(a) The emergent secondary radiation is examined, which is known to be much larger than the incident †, especially for thin sheets of light metals.

(b) No correction has to be made for scattered radiation, as the scattering of the primary beam must be nearly the same in both cases.

(c) The effect of the secondary radiation is of the same order as that of the primary rays; the latter always have to pass through the radiator, whether it is placed at A or B, whereas the secondary rays produced in the surface facing the electroscope and in the nearest layers are not absorbed at all or only to a slight extent by the radiator itself.

Iron, nickel, copper, and zinc were investigated in this way, the respective sheets having a thickness of 0.043, 0.058, 0.022, and 0.025 mm. These thicknesses, out of all available, proved the most suitable in order to obtain a comparatively large amount of secondary radiation. A large number of measurements had to be made, as the results were not obtained directly but by subtraction of two values, each of which might contain an experimental error of about 1 per cent. The case of copper is represented in fig. 2, where the logarithms of ionization are plotted against the thicknesses of

* Rutherford and Richardson, *Phil. Mag.* vol. xxvi. p. 324 (1913).

† J. A. Gray, *Proc. Roy. Soc., A.* vol. lxxxvi. p. 513 (1912).

the absorbing foils. In Table I. the values of μ/ρ in the four cases are given together with the corresponding values for "characteristic" X rays found by Barkla and Sadler *.

Fig. 2.

TABLE I.

Atomic weight.	Mass absorption coefficient μ/ρ in aluminium for	
	γ rays.	X rays.
Iron 55.8	91.3 cm. ⁻¹ Al	88.5 cm. ⁻¹ Al
Nickel 61.3	58.8	59.1
Copper 63.6	46.8	47.7
Zinc 65.4	39.8	39.4

It is seen that there is a close resemblance between the radiations in the two cases. The difference in values is not greater than the experimental error.

The amount of secondary radiation, never exceeding 5-6 divisions a minute, varied in the different cases, but was as a rule larger for the lighter radiators. In the case of elements heavier than zinc—namely, silver and tin—the secondary effect was too weak to be examined with the

* *Loc. cit.*

accuracy required. This seems to disagree with Gray's conclusion, for he found that the higher the atomic weight of radiator the larger the amount of secondary radiation *. The disagreement between the results is probably due to differences in the experimental arrangements: Gray measured the ionizing effect of rays which had passed through a certain thickness of iron used to cut out the primary β -rays; a large amount of soft γ radiation was absorbed at the same time and the effect of the lighter elements was therefore largely decreased in favour of the heavier elements, which give rise to harder rays. In addition Gray used a β -ray electroscope filled with air, whereas in the present investigation a very thin sheet of mica covered the face of the electroscope which contained the vapour of methyl iodide.

In order to examine the secondary radiation from silver and tin, a different arrangement was found more satisfactory, being simply an improvement of Gray's method as regards sensibility. The soft primary γ rays were cut out by a plate of carbon 5 mm. thick; this thickness was also sufficient to stop all primary β particles, so that no magnetic field was necessary; but to get rid of the electrons excited in the carbon and absorbers, it was necessary to cover the face of the electroscope with some cardboard. The incident secondary radiation was examined by placing the radiator immediately behind the source. Subtracting the effect without radiator from that with the radiator in position, when different absorbing foils are placed in the path of the rays, we obtain the values for the secondary radiation. The results are shown in Table II., and are in fairly good agreement with the values for the "K" radiation from silver and tin determined by Barkla.

TABLE II.

Atomic weight.	γ rays.	X rays.
Silver 107.9	2.6 (cm.) ⁻¹ Al	2.5 (cm.) ⁻¹ Al
Tin 119.0	1.6	1.57

From the results of Barkla, another softer radiation might be expected belonging to the "L" series, but this

* *Loc. cit.*

could not be detected with the experimental arrangement employed.

I wish to express my sincere thanks to Sir Ernest Rutherford for his help and advice.

Physical Laboratory,
The University, Manchester.
July 1914.

Note.—While these experiments were in progress, H. Richardson (Proc. Roy. Soc. A. xc. p. 521, 1914) has examined the secondary radiation excited in different elements by the β rays from an intense source containing radium B and radium C. The method he used was the same by which Chadwick* in 1912 had proved the existence of this radiation, but the experimental arrangement was more suitable to detect soft radiations. The mass absorption coefficient for the secondary rays excited in a large number of elements has been determined in this way. The values found for eleven comparatively light elements (atomic weights 58·8–137·4) show the same striking resemblance with the corresponding values obtained by Barkla for the “K” series of characteristic X rays, which has been pointed out in the present note. Six heavier elements (195·3–238) gave results very close to those found for the “L” series of characteristic rays. The few results obtained in the present investigation by using radium D and radium E, in addition to those obtained by Richardson, who used a quite different source of β radiation, leave no doubt as to the identity of secondary rays excited in the different substances by any stimulus, whether by β or X rays.

XIX. *On the most Effective Primary Capacity for Induction-coils and Tesla Coils.* By E. TAYLOR JONES, D.Sc., Professor of Physics in the University College of North Wales, Bangor†.

IN the theory put forward in recent papers‡ by the writer the induction-coil is regarded as an oscillation transformer, in which the two circuits are closely coupled, and in which the secondary potential arises from the superposition of two oscillations differing in amplitude,

* J. Chadwick, Phil. Mag. vol. xxiv. p. 594 (1912).

† Communicated by the Author.

‡ Phil. Mag. xxii. p. 706 (1911) [with D. E. Roberts]; xxvii. p. 565 (1914); xxix. p. 1 (1915).