LETTERS TO THE EDITOR.

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The Nature of the γ and X-Rays.

IN a previous letter to NATURE (January 23, p. 270) I gave a brief description of some experiments made by Dr. Madsen and myself on the properties of the secondary radiation due to γ rays. A fuller account is given in the Transactions of the Royal Society of South Australia, 1908, p. 1.

The experiments have been continued, and I hope that the following summary of the results will be of interest:—

(1) When γ radiation is diminished in quantity as it passes through matter, β radiation appears in its place, moving at the outset in the original direction of the γ radiation, and subsequently undergoing scattering in the ordinary manner of β rays.

(2) The penetration and therefore the speed of the β radiation thus produced increases with the penetration of the γ radiation to which it is due.

(3) The speed of the β radiation does not depend upon the nature of the atom in which it arises.

(4) In the case of radium at least, the speed of the β radiation is nearly equal to, perhaps a little less than, the speed of the normal β rays emitted by radium itself.

(5) When very hard γ rays traverse matter their absorption and therefore the production of β rays are almost independent of the atomic structure of the matter, and a density law follows. Softer rays are affected by atomic structure; they are more absorbed by heavy atoms than by light atoms for equal weights of absorbing screen. The softer the rays, the greater is this effect. Hence arises the difference in character of the logarithmic curves of absorption of different substances; heavy atoms show a rapid initial fall. Hence also when soft γ rays are used the emergence radiation from heavy atoms may be greater than from light atoms. And again, the relative extent to which the rays produce secondary radiation from different metals may be modified by passing the rays through screens, as Kleeman has shown. We do not, however, find any true selective absorption such as Kleeman suggests.

(6) If there are any secondary γ rays, the ionisation which they produce is negligible compared with that produced by the secondary β radiation, at least within a moderate distance of the radiator, say a metre in air.

All these facts can be explained very simply and directly on the neutral-pair theory; indeed, the theory guided us to the verification of most of them.

As regards (1), we have simply to suppose that the negative and positive passing united into an atom are separated if they happen to traverse a very strong field anywhere therein; the negative flies on, and the positive becomes ineffective.

The second property is also an obvious consequence of the hypothesis. The faster the γ particle is moving, the greater the initial speed of the negative.

The third is readily explainable: the electric field of the atom is merely the solvent of the bonds that connect the pair. It is not able to affect the speed of the negative set free.

The fourth may be taken to imply that the radio-active atom (say Ra C) ejects electrons at a certain speed, some of which start off in company with a positive counterpart, some without. The former constitute the γ rays, the latter the β.

The fifth would show that there are stronger fields inside heavy atoms than light ones, and that the chance of separation of the pair increases with (*a*) the strength of the field, (*b*) the time taken to cross it.

Turning now to the ether pulse hypothesis, it is convenient to consider it in two different forms, which are irreconcilable with each other.

In the first of these, both the electron and the electron's energy are supposed to be drawn from the atom, the γ ray merely pulling the trigger. This theory requires us to accept the extraordinary idea that the primary ray, though it does no more than pull the trigger, determines the direction and velocity of the shot, and it offers no explanation at all of (1) and (4) (see above). We should naturally expect the velocity of the electron to be a function of the properties of the atom from which it is drawn, as in the well-known cases of true radio-activity. Moreover, all the radio-activity of which we have certain knowledge is not to be hurried or stayed by any external agency. It is true that Prof. W. Wien (Göttingen *Nachrichten*, 1907, p. 598) has made a tentative application of a theory of Planck's, and thence derived a formula $v^2\lambda = \text{const.}$, where v is the velocity of the ejected electron, and λ the thickness of the pulse. This provides a formula, but it satisfies (2) and (3) only; moreover, it seems to me that the difficulties remain as great as ever, and that the application of Planck's theory must be unjustifiable.

Passing on to the second form of the pulse theory, we now suppose the electron itself to be drawn from the atom, but its energy from the pulse.

I understand that this view is now held by Prof. J. J. Thomson (see Camb. Phil. Soc., vol. xiv., part iv., p. 417), and it is also maintained by Mr. N. R. Campbell ("Modern Electrical Theory"). New works often take some time to reach us here, and I have only just received a copy of this admirable book, but I hope I have understood it sufficiently well to enable me to describe the position correctly.

Since the energy of a pulse, if spread over an ever-widening surface, is utterly insufficient to provide the energy required for the secondary β ray, Prof. Thomson and Mr. Campbell suggest that the pulse does not spread, but travels radially from the arrested electron along tubes of force, the latter being considered as things differentiated from the surrounding space. Prof. Thomson speaks of bundles of pulse energy travelling with the speed of light in straight lines. When a kathode particle strikes the anti-kathode, bundles dart away from the point of impact; when these impinge on atoms they drive out the electrons constituting the secondary rays. In this way the energy difficulty is explained, and possibly also the difference between the emergence and the incidence radiations. It must be remembered, however, that this difference may be very large. In the case of carbon under γ rays, the one radiation is five or six times the other. Since the secondary β ray has the same speed (nearly) as the primary kathode ray which caused the X-ray, it seems to me necessary to suppose that the arrest of the kathode particle must cause one bundle of energy of very small and invariable volume to travel out along one straight tube (and only one) connected to that particle. This causes the ejection of one electron from some atom into which it penetrates, giving all its energy to that electron. Similar arguments apply to β and γ rays. Surely it requires a very complicated structure of the æther to effect all this. I have too deep a respect for Prof. Thomson's work to say it is not possible to construct a theory on these lines, but I think I may fairly claim that the neutral-pair theory explains all the known properties of the γ rays much more simply and completely.

Perhaps I ought to add that the theory, although it may require a detachable positive electron, does not require a free positive electron.

I have scarcely mentioned the X-rays. I am glad to see that Mr. Cooksey (NATURE, April 2, p. 509) has proved the difference between emergence and incidence radiation in their case also. It can now be said, therefore, that all the properties of the γ rays as set out in the above summary hold for the X-rays also, *mutatis mutandis*.

University of Adelaide, May 5. W. H. BRAGG.

Symbols for Physical Quantities.

IT is very desirable to have a notation for the representation of physical quantities in scientific books and periodicals, which shall be the same in all languages.

The subject is under the consideration of the International Electrotechnical Commission with a view to international agreement, and committees in the different countries (in England under the chairmanship of Lord Rayleigh, O.M.)