(*Reprinted from* NATURE, *Vol.* 134, *page* 494, *September* 29, 1934.)

DETECTION OF NEUTRONS LIBERATED FROM BERYLLIUM BY GAMMA RAYS: A NEW TECHNIQUE FOR INDUCING RADIOACTIVITY

BY

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WE have observed that a radiation emitted from beryllium under the influence of radium gamma rays excites induced radioactivity in iodine, and we conclude that neutrons are liberated from beryllium by gamma rays.

Chadwick and Goldhaber were the first to observe a nuclear disintegration due to the action of gamma rays. In their pioneer experiment[1], they used a small ionisation chamber filled with heavy hydrogen and observed that protons were ejected from the heavy hydrogen under the influence of gamma rays from thorium C. Their method can be used for the detection of the gamma ray disintegrations of other elements, as such a disintegration would generally be accompanied by the ejection of *charged nuclei* which their method is designed to detect. On the other hand, apart from the unique case of heavy hydrogen, their method does not appear to give direct evidence on *neutron* radiations, which may in certain cases accompany gamma ray disintegrations.

It appeared to us of interest to search for such neutron radiations, and we thought that the Fermi effect might conveniently be used as an indicator of their presence. For certain reasons, we chose to use as indicators elements which, like iodine, are transmuted in the Fermi effect into their own radioactive isotopes.

In order to make our test more sensitive, we applied in this work the new principle of isotopic separation which we recently described[2]. In the present experiment we have used iodine as indicator, and separated radio-iodine from the bombarded iodine.

In one experiment we surrounded 150 mgm. of radium (in sealed containers of 1·0 mm. platinum filtration) with 25 gm. of beryllium, which was further surrounded by 100 c.c. ethyl iodide. The silver iodide precipitate obtained after irradiation from the ethyl iodide showed an activity decaying with a half period of 30 minutes. In spite of the inefficient geometrical arrangement of the beryllium in this experiment, we obtained from the active precipitate 200 impulses of the Geiger-Müller beta ray counter per minute. In the control experiment omitting the beryllium, we obtained less than 12 impulses per minute. The effect observed is sufficiently strong to be easily detected without separating chemically the radioactive element.

Our observations show that it will be possible to make experiments on induced radioactivity by using the gamma rays of sealed radium containers, which are available in many hospitals for therapeutic purposes. Further, it will be possible to have very much stronger sources of neutrons and to produce thereby larger quantities of radioactive elements by using X-rays from high-voltage electron tubes.

[1] NATURE, **134**, 237, Aug. 18, 1934.
[2] NATURE, **134**, 462, Sept. 22, 1934.

Printed in Great Britain by FISHER, KNIGHT & CO., LTD., St. Albans

Letters to the Editor

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Seeing in the Ultra-Violet

ACCORDING to different authors[1,2], under appropriate conditions seeing is possible in the ultra-violet down to a wave-length as small as 3100 A. This fact has been confirmed on 21 persons (age 25–50 years) using as light sources discharge tubes containing (1) high-pressure mercury, (2) low-pressure cadmium and zinc (both in neon). The tubes were of quartz, 15 mm. × 120 mm. Visible light and short waves (<2700) were cut out by a red purple corex filter. Using one or more filters (each 5 mm.) the intensity of the Hg line 4047 relative to 3650 and 3130 could be varied within wide limits. A small monochromator

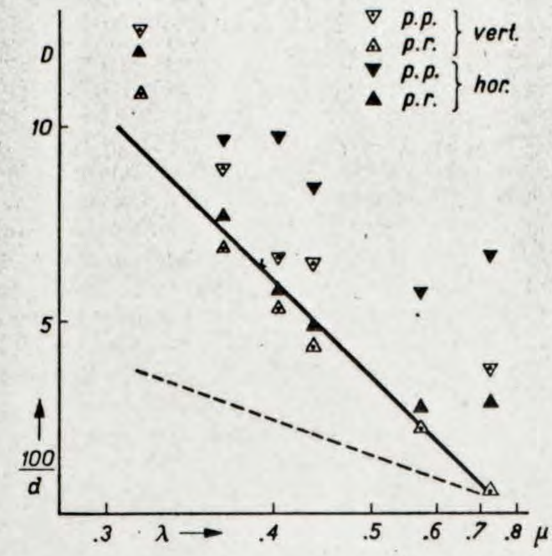

FIG. 1. Distance in dioptres of the *punctum remotum* and *proximum* of the author's left eye for vertical and horizontal focal line, λ 7080 – 3130. The dotted line refers to the refractivity of water (Listings eye).

(without second slit) was used to separate the different wave-lengths. As a result, the visibility for λ = 3650 relative to 4047 could be determined. It was also possible to estimate the visibility for 3130.

The values are very different for different persons.

$$V_{3650}/V_{4047} = 0{\cdot}015 - 0{\cdot}0003$$
$$V_{3130}/V_{4047} = 0{\cdot}005 - 0{\cdot}000004$$

One person could not see 3650, three persons were unable to see 3130. Even the most sensitive persons could not see the Zn line 3076. The Zn triplet 3345–3282, the Cd triplet 3612–3403 and the Cd line 3261 were seen by them with great ease. The description which these persons gave of the colour is very remarkable. They described it as clear blue, whereas the Hg line 4047 and the Zn line 4057 were described as violet. It seemed to them as if the succession in the spectrum was reversed[3]. To myself the colour appeared more greyish, although with a hue distinctly bluer than that of the recognised 'violet' lines (my visibilities are 0·0003 and 0·00002). The intensities used (expressed in mwatt/cm.² steradian) were

Hg 4047 (36)	3650 (60)	3341 (5)	3130 (50)
Cd 3612 (8)	3466 (8)	3403 (3)	3261 (100)
Zn 3345 – 3282 (10)		3076 (10)	

At the same time the dispersion of the eye could be studied by determining the distance (d) for which the image of the slit in a certain wave-length is seen sharply with the unaccommodated and well-accommodated eye respectively (*punctum remotum* and *proximum*). The reciprocal of the *p.r.* distance proved to be a nearly linear function of $1/\lambda$ from λ = 7082 to λ = 3130 A. For an eye which is emmetropic in the red, the degree of myopy at λ = 3130 A. amounts to about 10 D. From this it results that the dispersion in the region covered by the measurements is about 2½ times that of water. A slight indication of anomalous dispersion at λ = 3130 is present. By adjusting a horizontal cross wire perpendicular to the slit, the influence of astigmatism could be investigated. The accompanying diagram (Fig. 1) shows the results for my own left eye, which happens to be astigmatic with a nearly vertical axis.

From the description of these experiments, it will be clear that real retinal vision is observed and not the fluorescence of the other parts of the eye such as the lens, which of course was also very strong.

Whether the retinal process is due to the cones or to the rods and if fluorescence of the retina plays a rôle are still open questions[4].

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[1] Helmholtz, cf. Kayser, "Hb. d. Spektroskopie", 1, 600; 1900.
[2] Nutting, "Outlines of Applied Optics". Cf. W. Graham, *J. Opt. Soc. Am.*, 6, 605; 1922.
[3] cf. Helmholtz, "Physiol. Optik", 3 Aufl., 2, 61.
[4] Helmholtz, l.c.

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[1] NATURE, **134**, 237, Aug. 18, 1934.
[2] NATURE, **134**, 462, Sept. 22, 1934.

Annihilation Radiation from Paraffin Bombarded with Neutrons

LEA[1] has shown that paraffin when bombarded with neutrons from a (Po + Be) source emits heterogeneous γ-radiation of quantum energy 2-4 × 10^6 e.v. By bombarding graphite with the same radiation and by testing paraffin with the γ-radiation of ThC″ it was shown that the effect was due to impacts between the bombarding neutrons and protons and it was, therefore, suggested that the γ-radiation arose as a result of the union of a proton and neutron to form a diplon.

However, if the γ-radiation arose in this manner, evidence of the recoil tracks of diplons should be found by means of the expansion chamber and stereoscopic photography, and the short tracks due to diplons should be mainly directed away from the neutron source. But the distribution found by Auger and Monod-Herzen[2] shows, on the contrary, a minimum in this direction, and in addition observations by Auger[3] have indicated that the tracks are due to recoil protons. Auger[3], and more recently Chadwick and Goldhaber[4], have therefore concluded that the γ-radiation does not arise as suggested. Auger suggests that it arises as a result of the excitation of the protons by inelastic collisions with the bombarding neutrons, although this could only involve the neutrons of highest energy or those which could excite the proton to higher energy states by resonance.

Perrin[5] has shown, however, that a particle of mass M_1 may produce a pair of electrons on colliding with a particle at rest of mass M_2 if its kinetic energy is greater than $2m_0c^2 \dfrac{(M_1 + M_2 + m_0)}{M_1} = 2 \times 10^6$ e.v. for particles of equal mass, which is much greater than that of the electron.

Thus, as the neutrons used by Lea and Auger had energies 2–4 × 10^6 e.v., electron pairs might be produced as a result of collisions between the incident particles and the protons. The negative electron of the pair being produced in the positive nuclear field of the proton might be captured, the positron of the proton being annihilated with this electron to produce a quantum of γ-radiation, the proton being thus transformed into a neutron. The heterogeneity of the γ-rays observed would then be due to the fact that there are four bodies involved in the action, the incident neutron, the newly-formed neutron, the recoil positive electron of the pair and the quantum.

If this explanation is correct we should also expect to observe γ-radiation of energy 0·5 × 10^6 e.v. due to the annihilation of the positron produced. In addition, the minimum number of recoil protons in the forward direction is thus due to the transformation of these particles into neutrons, as the probability of the action would be much greater in cases of direct impact.

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[1] Lea, NATURE, **133**, 24, Jan. 6, 1934.
[2] Auger and Monod-Herzen, *Comptes rendus*, **196**, 543; 1933.
[3] Auger, *Comptes rendus*, **198**, 365; 1934.
[4] Chadwick and Goldhaber, NATURE, **134**, 237, Aug. 18, 1934.
[5] Perrin, *Comptes rendus*, **197**, 1302; 1933.

Electric Arcs with Fused Metals and Salts as Electrodes

ONE of us (M.P.) announced in a letter to NATURE two years ago[1] that electric arcs had been obtained between electrodes of substances which are insulators at ordinary temperature. By heating glass, porcelain, quartz, etc., to a very high temperature, it is possible to start the arc between electrodes of these substances.

We have now extended these researches. Metals and metallic salts, fused in a carbon crucible—fusion is brought about by previously starting the arc between the negative carbon above and the positive carbon crucible—which is connected with the positive or negative pole of a powerful battery of accumulators, can be positive or negative electrodes of an arc.

The properties of these arcs vary greatly. For example, with molten sodium, or sodium salts as positive electrode, the arc appears spectroscopically at its start, as a flame. The spectrum is restricted to D_1D_2, which appears as a single line. Presently, the spectrum becomes richer. The D doublet appears as a very large, luminous line, that sometimes broadens to some thousands of angstroms, so that it invades all the visible region of the spectrum, with a large zone of autoinversion at the centre, which reaches, at times, a width of 500 A. Moreover, the lines of the accessory series also appear and are autoinverted.