Induced Radioactivity of Nickel and Cobalt

USING nickel as a receiving plate for the recoil of radio-elements produced in the Fermi effect I have found, contrary to the statements of Fermi and his co-workers[1], that this metal acquires a slight activity under neutron bombardment. This effect must be attributed to nickel, because it is exhibited by chemically pure nickel plates and nickel oxide. Further investigations have shown that the induced radioactivity of nickel is composed of two parts, one decaying with a period of about 20 minutes and another with a period of the order of a few hours. The activity of both products is very small: nickel plates of 0·1 mm. thickness exposed for 12 hours to the full neutron radiation of 40 millicuries of radon mixed with beryllium give an initial effect of 1·5 impulses per minute. The long-life activity is enhanced 4–5 times, when neutrons are allowed to pass through water; the short-period product shows no increase in this case. It is therefore probable that the first product is an isotope of nickel. The possible reactions leading to this product are:

$$_{28}\mathrm{Ni}^{58} + {_0}n^1 = {_{28}}\mathrm{Ni}^{59} \quad . \quad . \quad . \quad (1)$$
$$\text{and } _{28}\mathrm{Ni}^{62} + {_0}n^1 = {_{28}}\mathrm{Ni}^{63} \quad . \quad . \quad . \quad (2).$$

Reaction (2) is more probable since its end product would be the stable isotope 63 of copper. The small relative importance of Ni^{62} in nickel would account for the smallness of the effect observed.

As for the second product of about 20 min. period, I have been led, on the ground of some rules based on a survey of artificial radio-elements, to the following reaction:

$$_{28}\mathrm{Ni}^{60} + {_0}n^1 = {_{27}}\mathrm{Co}^{60} + {_1}\mathrm{H}^1.$$

In order to test this assumption, I have irradiated cobalt in a large vessel containing water. In addition to the known radio-element Mn^{56} of about 2·5 hours period[1] I have found another activity which has a period of about 20 minutes and which does not appear when no hydrogen medium is used. The initial activity due to this product is of the order of 6 impulses per minute. The corresponding reaction must be:

$$_{27}\mathrm{Co}^{59} + {_0}n^1 = {_{27}}\mathrm{Co}^{60}.$$

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[1] E. Fermi, E. Amaldi, O. D'Agostino, F. Rasetti, E. Segrè, *Proc. Roy. Soc.*, A, **146**, 483; 1934. **149**, 522; 1935.

Spiral Orbits and the Law of Recession

FROM certain considerations of isotropy, one of us has obtained, in a paper communicated elsewhere for publication, the line-element

$$ds^2 = -e^{\mu}(dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta d\varphi^2) + e^{\nu} dt^2, \quad . \quad (1)$$

where $\mu = \log(A + Bt + \frac{1}{2}t^2)$ and $\nu = 2 \log r$, A and B being arbitrary constants of integration. If $A = B = 0$, the geodesics give a straight line motion according to the law

$$\dot{r}/r = c/t, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where $c = -2$ or $\pm\sqrt{2}$. The two-dimensional motion is given by $\dot{r}/r = D/t$, and $\dot{\varphi} = \sqrt{(2-D^2)}/t$, . . (3)

so that $rd\varphi/dr = \sqrt{(2-D^2)}/D$, ... (4)

which gives an equiangular spiral. If the spiral structure of the nebulæ is due to particles describing equiangular spirals as given by (4), and if the law of recession of the nebulæ themselves is of the form (2), then the line-element (1) seems to be of great interest in the relativistic theory of world-structure.

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Density of 100 per cent Heavy Water

THE density of D_2O was firstly estimated by Lewis and Macdonald[1] to be: $d^{25}_{25} = 1{\cdot}1056$. Later Taylor and Selwood[2] found a higher number: $d^{25}_{25} = 1{\cdot}1079$, and this figure has been used by several investigators. However, during the technical progress of concentration at the plant of the Norsk Hydro-Elektrisk Kvælstof A/S at Rjukan, indications were obtained that this figure was too high, and a number of careful pyknometer determinations of the density of 100 per cent D_2O in large quantities were, therefore, conducted.

The results obtained for the normal 100 per cent D_2O product (for which the density of the distilled electrolyte and that resulting from the combustion of hydrogen and oxygen from the cells were identical) were as follows:

$$d^{20}_{20} = 1{\cdot}10711;\ 1{\cdot}10712;\ 1{\cdot}10713;\ 1{\cdot}10714,$$

of which the highest figure ($d^{20}_{20} = 1{\cdot}10714$) must be considered to be the nearest approach to the true value. The pyknometer determinations were correct to 0·000001. The value of the density obtained corresponds to $d^{25}_{25} = 1{\cdot}1074$, that is, actually considerably lower than Taylor and Selwood's figure.

In order to determine the content of heavy oxygen in the water employed, 100 per cent D_2-gas was lead over hot copper oxide containing the normal O^{16}/O^{18}-ratio. The resulting water had a density: $d^{20}_{20} = 1{\cdot}1070$, and consequently the isotopic ratio of the oxygen in the 100 per cent D_2O products does not differ appreciably from the ordinary ratio. Concentration of heavy oxygen during electrolysis of water is, however, actually found to take place under certain conditions[3,4], and the high figure of Taylor and Selwood for the density of heavy water may be due to a higher proportion of heavy oxygen in the samples employed.

On the other hand, the density of 'light water' with a D_2O-content less than 1 : 200000 has also been determined. d^{20}_{20} for this product was found to be $0{\cdot}9999815 \pm 1\,\gamma$.

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[1] Lewis and Macdonald, *J. Amer. Chem. Soc.*, **55**, 3057; 1933.
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[4] Johnston, *J. Amer. Chem. Soc.*, **57**, 484; 1935.