Letters to the Editor.

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The Corpuscular Explanation of Cosmic Rays.

WITH reference to the attempts that are being made to determine whether the cosmic radiations are corpuscular or undulatory in character, such as those described by Bruno Rossi,¹ there is one point which I have vainly tried to understand. Why is it assumed that such rays would or could have the high penetrating power of cosmic rays? As I tried without success to point out at the recent discussion at the Royal Society, there is no experimental evidence of corpuscular rays being able to traverse more than 4 mm. of aluminium. It is, of course, known that a few of the β -rays of radium and thorium have energies, as measured by their magnetic deviability, up to some millions of volts. But what experimental evidence is there that these have greater penetrating power than rays of lower energy? Is it not rather to be expected that it would be less, or do the ordinary conceptions of relativity not apply to the theory of relativity? If we try to get the necessary penetrating power by the increase of mass of the particle due to its speed, is not the mass of every other particle with which it collides similarly increased?

FREDERICK SODDY.

Oxford, Aug. 22, 1931.

¹ NATURE, 128, 300, Aug. 22, 1931.

Measurements on the Absorption of the Penetrating Corpuscular Rays coming from Inclined Directions.

IN a recent discussion on the cosmic rays,¹ Prof. Geiger has pointed out that it would be of interest to make comparative measurements on the absorption of the penetrating corpuscular rays coming from different inclinations to the vertical.

Such an experiment was performed by me shortly before I read this paper, by measuring the diminution in the number of coincidences when a screen of lead 9 cm. thick was introduced between two Geiger-Müller's tube-counters (5 cm. in diameter and 15 cm. long) placed with their axes horizontally, at a distance of 17 cm.

By inclining more and more to the vertical line the plane containing the axes of the two tube-counters, thus increasing the thickness of the atmosphere in the direction of those rays which can determine the coincidences, I expected to find a progressive hardening of the corpuscular radiation, similar to the one which had been stated, by filtering the radiation through a lead screen.²

The experimental result did not confirm this expectation. Indeed, with the two counters placed vertically the one above the other, I measured an absorption of 23.2 ± 1.6 per cent; whilst when the plane of their axes was put at an angle of 60° to the vertical line, the absorption was found to be 32.5 ± 3.5 per cent.

It appears, therefore, that the slant rays are softer and not harder than the vertical ones.

This result may be accounted for by assuming that the corpuscular rays generate in the atmosphere a

softer secondary corpuscular radiation, and that the relative amount of the latter is in an inclined direction larger than in the vertical one.

BRUNO ROSSI.

Physical Institute of the
University of Florence,
Arcetri, Italy, Aug. 10.

¹ NATURE, May 23, p. 785; *Proc. Roy. Soc.*, July 2.
² B. Rossi, *Zeit. für Phys.*, 68, 64; 1931; and *Rend. Lincei*, 13, 600; 1931.

Isotopic Displacement in Hyperfine Structure.

THE analysis of the hyperfine structure of several lines in thallium¹ indicates the existence of two distinct sets of energy levels, one for Tl 203 and the other for Tl 205. Each isotope has a nuclear spin $i = \frac{1}{2}$. For the line $6s\ 7s\ ^3S_1 \rightarrow 6s\ 7p\ ^1P_1$ in Tl II, the doublet width is approximately the same size for the two isotopes, which signifies that the magnetic moments must also be approximately equal. The distance between the centres of gravity of the two doublets, however, is greater for Tl 205. Jackson,² studying rubidium, concludes that the lines are displaced toward the ultra-violet for the heavier isotope.

From existing theories of hyperfine structure, one is led to conclude that such a bodily displacement would occur even when both isotopes have zero magnetic moment. Experimental evidence as to this would be valuable.

It appears, then, plausible to assume that the electric field produced by the nucleus is not the same for the two isotopes. Whether the thallium nucleus, with a spin $i = \frac{1}{2}$, can have either a permanent dipole moment or a permanent higher moment is doubtful, if one may make an analogy with the case for the external electronic system.³ Accordingly, the discussion will be confined to central fields, the difference between the two being in the radial dependence of the potential energy.

In order to determine the order of magnitude of the perturbation on a Schrödinger electron by deviations from the Coulomb law near the nucleus, it is probably sufficient to assume a potential energy curve as follows: $V = V_0$ for $r < r_m$, and $V = -\frac{Ze^2}{r}$ for $r > r_m$, where r_m indicates the radial extent of the nucleus. Since calculation showed that relativistic effects would not influence the result appreciably, the following treatment will not take them into account.

Sommerfeld ("Ergänzungsband", p. 75) gives the radial function as $R = \frac{1}{N_r} \rho^l e^{-\rho/2} L_{n-l}^{2l+1}$, where $\rho = \frac{2Zr}{n}$ and $\frac{1}{N_r^2} = \frac{4(n-l-1)!}{n[(n+l)!]^3}$.

Atomic units are employed.

In the range from 0 to r_m , $\rho \ll 1$ and $e^{-\rho/2} \approx 1$. Consequently the only part of the Laguerre polynomial which makes an appreciable contribution is the constant term.

If w_1 and w_2 are the displacements of a $7s$ energy level, and of a $7p$ energy level respectively, then

$$w_1 = \frac{1}{N_r^2} \int_0^{r_m} \left(\frac{Z}{r} + V_0 \right) r^2 dr [L_7^1(\rho)]^2 \approx 2Zr_m^2 + \frac{1}{3}V_0r_m^3$$

$$w_2 = \frac{1}{N_r^2} \int_0^{r_m} \left(\frac{Z}{r} + V_0 \right) r^2 dr [L_8^3(\rho)]^2 \approx \frac{1}{3}K^2Zr_m^4 + \frac{1}{15}K^2V_0r_m^5$$

where $K = \frac{2Z}{n}$.

The displacement w_1 is much greater than w_2 ,