On the Magnetic Deflection of Cosmic Rays

In a recent letter to this section, L. M. Mott-Smith[1] proposed an experiment for deflecting the cosmic rays in a magnetic field which made use of the magnetic induction in the inside of a magnetized iron bar.

This experiment has recently been performed by the writer, using identically the same arrangement and has been shortly described in "Rendicouti della R. Accademia Naxionale dei Lincei", Vol. XI, p. 478, March 1930.

Due to the exceedingly small frequency of coincidences, it was not possible during this first experiment to attain such an accuracy that the expected effect of electrons having a velocity of 10^9 volts lay outside of the average error. A new and more complete experimental set-up is at present under construction and will allow the application of the old method, as well as of a new method (for which Prof. Puccianti is to be thanked). The latter is based on the following principle. Above and below two oppositively magnetized iron bars, which lie close to each other in a horizontal plane, there are placed two counters with their axes parallel to the direction of magnetization. The electrons, passing through the upper counter will be either concentrated upon or deflected away from the lower counter, depending on the direction of magnetization.

Calculation has shown that, for a given size and separation of the counting-tubes, a much larger effect is to be expected from the latter method than from the former.

Moreover, for the explanation of such experiments, there are certain difficulties, which I (as well as L. M. Mott-Smith) did not consider at first. Namely, although the induction represents the average value of the microscopic magnetic field strength, it is probably not allowable *apriori* to assume that this average value is the true value which causes the electron deviation. An exact theoretical treatment of the problem has not been presented.

If the primary cosmic rays are an electron radiation, then (as has already been noted)[2] the earth's magnetic field must also be considered. The effect of the earth's field should be noticeable by an unsymmetric directional distribution of the intensity with respect to the perpendicular. Experiments are being prepared which will test such an effect.

Let us call V the velocity of the electrons in volts, R the earth's radius, M the magnetic moment of the earth, λ the magnetic latitude at the point of observation, θ the angle between the plane of the magnetic meridian and the direction of the path of the electrons (positive toward the east), a a constant, whose value is approximately 3×10^2. Then the theory gives the following results. Electrons may impinge at a definite point of the earth's surface (when $V<aM/R^2$) only if the angle θ satisfies the following inequality:

$$\text{Sin}\,\theta > \frac{aM}{R^2V}\cos\lambda - \left(\frac{aM}{R^2V}\right)^{1/2}\frac{2}{\cos\lambda}$$

For example at a point where the magnetic latitude is $\lambda=45°$, if $(aM/R^2V)=16$ the above condition shows $\sin\theta>0$. This means that the whole region west of the magnetic meridian is "in shadow". This case comes into consideration for electrons having a velocity of about 4.3×10^9 volt.

If $(aM/R^2V)\cos\lambda-(aM/R^2V)^{1/2}\,2/\cos\lambda>1$ the above inequality has no solution. This means that electrons can never impinge upon the point under consideration.

Here, however, diffusion and loss of velocity in the earth's atmosphere have not been taken into account.

Bruno Rossi

Physikalisch-Technische Reichsanstalt,
Charlottenburg, Berlin, Germany.

July 3, 1930.

[1] L. M. Mott-Smith, Phys. Rev. **35**, 1125 (1930).

[2] Bothe u. Kolhörster, Das Wesen der Höhenstrahlung Zeits. f. Physik **56**, 489 (1929).