electron and temperatures as high as 40,000,000° unless the constant b could be shown to have an enormous value.

[1] For references to the work of Friedman, LeMaitre, Robertson, Tolman, Eddington and de Sitter in this field, see Tolman, *Proc. Nat. Acad. Sci.*, **16**, 582 (1930).

[2] Stern, *Zeits. Electrochem.*, **31**, 448 (1925); *Trans. Faraday Soc.*, **21**, 477 (1925–26).

[3] Tolman, *Proc. Nat. Acad. Sci.*, **12**, 670 (1926).

[4] Tolman, *Phys. Rev.*, **35**, 904 (1930).

[5] Tolman, *Proc. Nat. Acad. Sci.*, **14**, 353 (1928).

[6] Tolman, *Ibid.*, **16**, 320 (1930).

[7] Einstein, *Berl. Ber.*, 1918, p. 448.

[8] Tolman, *Proc. Nat. Acad. Sci.*, **16**, 409 (1930), Equations (2).

[9] Tolman, *Ibid.*, **14**, 701 (1928); *Phys. Rev.*, **35**, 896 (1930).

ANSWER TO PROF. STÖRMER'S REMARK

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Referring to my "Note on the Nature of Cosmic Rays,"[1] Prof. Störmer draws attention to the fact[2] that he had treated the problems of the motion of electrons in the magnetic field of the earth many years ago. He gives the complete list of his publications on the subject and, indeed, I must confess that I was not aware of his work on the particular phase of the problem to which my note is devoted.

But if I am guilty of having overlooked Prof. Störmer's priority, I may claim extenuating circumstances on several counts, and I believe that my note was not quite superfluous. *In the first place*, Prof. Störmer's papers appeared in magazines which are not readily accessible to the physicist. Even now, after the bibliography has been given by him, I have no access to that of his publications (Geneva, 1907) which contains the data, answering the questions put in my note, or the formulas from which these data could be derived. As all my colleagues in Southern California, and many in other places, are in the same position, it was well to restate the problem and its solution.

In the second place, Prof. Störmer's work dates from pre-relativistic days and is, therefore, based on classical mechanics while my note takes into account relativity. For the high velocities in question, one expects, at first sight, greatly different results. That Prof. Störmer's result is of interest also in the relativistic case is surprising and requires an explanation. The analysis can be based on the Hamilton-Jacobi partial differential equation. In the case of a magnetic dipole, acting upon one electron, this differential equation has the same form for the classical and for the relativistic treatment. However, the two constants entering into the equation are widely different in the two treatments. The limiting value of the distance from the magnetic pole, which was determined by Prof. Störmer and by myself, depends only on one of these constants denoted by A in my note. The physical meaning of this constant is the absolute value of the momentum. In terms of the kinetic energy α and of the rest mass m, it has the following expressions

$$A^2 = 2m\alpha + \alpha^2/c^2, \quad \text{relativistic}$$
$$A^2 = 2m\alpha, \quad \text{classical}$$

If we express the limiting angle as a function of the energy or of the velocity of the electrons, the results in the two theories are vastly different. However, Prof. Störmer expresses it as a function of the "magnetic rigidity" aH, where a means the radius of the circle which the electron would describe in a homogeneous field of the strength H. The connection between the magnetic rigidity and the momentum is given by the equations (notations as in the note)

$$mv/\sqrt{1 - \beta^2} = eaH/c, \quad \text{relativistic}$$
$$mv = eaH/c, \quad \text{classical}$$

The left sides of both equations represent the momentum and are equal to our constant A. We find, therefore, in both cases

$$A = aHe/c.$$

The constant A is, therefore, directly proportional to the magnetic rigidity. If we plot the maximum angle against the magnetic rigidity we get the same curve in the classical and in the relativistic treatment.

In conclusion, I take the opportunity for correcting an erratum: in formulas (18) and (21) of the "Note," read under the square root $1 + \sin^3 \vartheta$ instead of $1 + \sin^2 \vartheta$.

[1] P. S. Epstein, these PROCEEDINGS, **16**, p. 658, 1930.

[2] Carl Störmer, *Ibid.*, **17**, p. 62, 1931.