proton into a positron under emission of light quanta of the order of magnitude $Mc^2 \sim 2,000 mc^2$ or 1,000 millions of electron volts, as are actually found in cosmic rays.

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¹ M. Born, *NATURE*, **132**, 282; 1933. *Proc. Roy. Soc., A*, **143**, 410; 1934.

M. Born and L. Infeld, *Proc. Roy. Soc., A*, **144**, 425; 1934. *A*, **147**, 522; 1934. *A*, **150**, 141; 1935.

² Pryce's paper has not appeared yet. As we are now widely separated, he in America, I in India, I publish this confirmation of his idea without asking his consent.

³ M. Born and E. Schrödinger, *NATURE*, **135**, 342; 1935.

Frequency of Collision of Electrons in the Ionosphere

MESSRS. FARMER and Ratcliffe¹ criticise my results on this subject² on the ground that I have neglected the effect of a possible variation of the E layer attenuation during the three-quarters of an hour or so in which the observations were taken. Such a variation of E layer attenuation would involve a spurious contribution to the slope of the $\log \rho$, P' curve, which would invalidate the calculation of the collision frequency. But where the reflection coefficient ρ decreases to a minimum and rises again (as in all cases observed), there are two branches to the $\log \rho$, P' curve, one corresponding to ρ decreasing and the other to ρ increasing, and the effect of a continuous variation of E layer attenuation would be to increase the slope of one branch and decrease that of the other by the same amount. The effect of the variation of E layer attenuation is therefore automatically eliminated in taking the mean of the slopes of the two branches.

In actual results obtained where both branches are clearly defined, there is no significant difference between the slopes of the two branches (so far as the accuracy of the observation allows) so that the effect of the variation of E layer attenuation is certainly small.

Prof. Appleton's criticisms³ are more fundamental, for he considers the formula from which the collision frequency is derived to be unjustified. My formula

$$\log \rho = \frac{-v_c}{2c} P'$$

formula $\log \rho = \frac{-v_c}{2c} (P' - P)$, and Prof. Appleton considers that the neglect of P may introduce considerable error, especially when P is of the same order of magnitude as P' .

It should be noted, however, that in the application to the determination of v_c by my method, I am not so much concerned with the total reflection coefficient or equivalent path P' , as with the changes $\delta \log \rho$ and $\delta P'$ occasioned by alterations in the layer as the maximum critical frequency ν_m approaches the frequency ν of transmission. As ν_m approaches ν , P' rapidly increases, if not to an infinite value at least to a very large value, while P tends to a definite limit. It follows that in the limit, as the critical frequency is approached, $\delta P'$ tends to a large value compared with δP , and the relation

$$\delta \log \rho = \frac{-v_c}{2c} \delta P'$$

ordinary ray, while $\delta \log \rho = \frac{-v_c}{2c} \frac{\delta P'}{1 - \tau/2}$ for the extraordinary ray. Thus the slope of the $\log \rho$, P' curve gives v_c quite accurately.

In order to test the accuracy of this relation, some examples have been worked out in which no approximation is made other than that involved in the assumption that $\alpha = \frac{v_c}{\beta \pi \nu}$ is small. The attenuation and

group time derived from the real and imaginary parts of the refractive index were integrated by quadratures, and the relation between $\log \rho$ and P' was determined. The distributions of electronic concentrations in the layer considered were those which start from zero, reach a maximum at a height z_0 , and then decrease. A typical example is shown in Fig. 1, in which $\log \rho / \frac{2\tau \alpha z_0}{\lambda}$ is plotted against $\frac{P'}{2z_0}$.

In accordance with relation (1) the curve should, for large values of P' , tend to a straight line the slope of which is unity for the ordinary ray and $1/(1 - \tau/2)$ for the extraordinary ray.

FIG. 1.

This is actually the case for the curve, which is calculated for the extraordinary ray with $\tau^2 = 0.1$. The slope of the curve is constant for values of $P'/2z_0 > 4$ and agrees with $1/(1 - \tau/2) = 1.187$ within the errors of the graphical representation.

This general theoretical reasoning, backed by numerical examples, demonstrates clearly that the method given is quite accurate for the purpose of determining the collision frequency.

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¹ *NATURE*, **135**, 585; 1935.

² *NATURE*, **135**, 435; 1935.

³ *NATURE*, **135**, 618; 1935.

Multiplanar Cyclohexane Rings

THE claim of Dr. Qudrat-i-Khuda¹ to the isolation of the four stereoisomeric forms of 1-carboxy-4-methylcyclohexane-1-acetic acid required by the Sasche-Mohr hypothesis which it has not been possible to substantiate in this laboratory² led us to search for further possible examples of this