A Photographic Method of Estimating the Mass of the Mesotron

WE have described[1] a method of estimating the mass of secondary particles with heavy ionization tracks in photographic emulsion which are due to some component of the cosmic ray. The method is based upon the determination of the kinetic energies of these particles and of protons with the same initial velocities, which according to our assumption produce tracks with the same mean grain spacings in the emulsion.

The method used requires to be amended in two ways:

(1) In the application of Williams's formula for scattering[2], which can be written as $\bar{\theta} = A.\frac{Ze^2}{W}\sqrt{Nt}$ in a medium with atoms of one kind, Z is the nuclear charge and N the number of atoms per unit volume. For the photographic emulsion, we have to sum up for the scattering due to the different kinds of atom with different values of Z. For this purpose we used a mean value of Z defined as $\bar{Z}.N = \sum_1^n Z_k N_k$. Since the value of $\bar{\theta}$ is deduced from that of $\bar{\theta}^2$ which is defined as $\frac{2}{\pi}$ times the mean square of θ, the value of Z to be used in our formula is the root mean square of Z, namely, $\overline{Z^2}.N = \sum_1^k Z_k^2 N_k$. While $\bar{Z}$ is 6·2, $\sqrt{\overline{Z^2}}$ is 11·3. This was pointed out to us by Dr. H. J. Bhabha in a private communication, for which our thanks are due to him.

(2) The second correction refers to the way the lengths of the ionization tracks in the emulsion were grouped together in the table given in our previous communication. There was a certain arbitrariness in our method of grouping, which while giving a series of more or less concordant values of the mesotron mass, is not sufficiently randomized. In the present calculation all the tracks are grouped together for which the mean grain spacings lie within definite ranges of 6–5, 5–4, 4–3, 3–2 μ. Further, we have used three more photographic plates exposed to neutron radiation from a radium-beryllium source to obtain a more accurate calibration curve for proton tracks.

The recalculated values of the mesotron mass are given in the accompanying table, for which A has been taken to be 3·69. If the more accurate formula (40) of Williams is taken, in which a correction for the finite nuclear radius is introduced, the value of A becomes 4·14, which raises the value of μ by 12 per cent.

Mean grain spacing 10^{-4} cm.		6–5	5–4	4–3	3–2	Mean value
Value of mesotron mass μ in units of m_0	Plate A	221	160	236	(1723)	217 ± 30
	B		316	355		336 ± 19·5
	C	278	318	342	(1743)	313 ± 18·6

Plate A was kept under air, and B under 20 cm. of water at Sandakphu, and plate C at Phari Jong, Tibet, in the Post Office building under a roof thickness of 2½ ft. of mud and wood. The consistently high values of mesotron masses found with plates B and C are probably due to the presence of proton tracks in these plates, due to collision of primary neutrons with hydrogenous matter. This is further evidence of the paucity of fast primary protons in comparison to the number of similar neutrons in the cosmic ray. In all the plates for mean grain spacing 3–2 μ, the tracks are largely due to protons; in this region the proton calibration curve is not accurate.

We have also determined the mass of the mesotron from the curvatures of the pair tracks in the emulsion; the value is found to be 186·0 m_0. Owing to the shortness of range in the emulsion of most of the star-tracks, similar determinations have not been possible with such tracks.

It is to be noted that in the calculations with Williams's formula we have used individual values of θ, rather than its mean value; this is conditioned by the nature of our investigation. The values of μ so obtained will be distributed statistically about the true value; the mean value of μ obtained for the set of observations with plate A will approximate closer to the true value than any of the individual ones.

As stated in our previous communications, the importance of these results lies in the support they give to the view that multiple mesotron production in a single act by some component of the cosmic ray is possible, the principal contributor being, according to our results, the neutron. This is in accordance with the views of Heisenberg. Further interest has been directed to this process by the recent investigations carried out in the United States, which have led to an attempt by Carlson and Schein[3] to explain the totality of the cosmic ray processes taking place in the earth's atmosphere as being due to the impact of a single primary particle, the proton. According to their views, the initial step consists in the creation in one explosive act of a large number of mesotrons, in which the primary proton by interaction with a nuclear particle in the upper atmosphere loses all its energy. So far as the creation of mesotrons is concerned, protons and neutrons are about equally effective. Our results appear then as an experimental support of Carlson and Schein's assumption. The further question then arises whether the fast neutrons which are found in the earth's atmosphere are entirely of secondary origin.

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[1] NATURE, 148, 259 (1941).
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Self-incompatibility in Polyploid Forms of Brassica and Raphanus

IN a recent paper Lewis and Modlibowska[1] have suggested that in autotetraploid pears pollen of the constitution S_1S_2 is capable of functioning in $S_1S_1S_2S_2$ styles—thus a self-incompatible diploid of the constitution S_1S_2 will produce by somatic doubling a self-compatible autotetraploid $S_1S_1S_2S_2$. In colchicine experiments I have observed many times that no such change occurs in *Brassica Rapa*, *B.*