LETTERS TO THE EDITORS

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Concerning New Elementary Particles in Cosmic Rays

AN analysis of the composition of cosmic rays at an altitude of 3,250 m. above sea-level (Alagez) which we carried out in 1946 revealed the existence of a noticeable number of particles with masses exceeding that of the meson. This result was obtained by applying a direct method of determining the mass of fast particles, according to their deflexion in a magnetic field and their range as found by absorption experiments. It was shown that almost 10 per cent of the particles of the cosmic rays have masses lying between 250 and 2,000 electron masses. These results were published in Russian in December 1946 [1] and in English in January 1947 [2]. We suggested calling this group of elementary particles 'varytrons', stressing in this way the diversity of masses of the new particles. A month later, in February 1947, in an article in English[3], we presented some evidence which proved that there exist in the cosmic rays positive and negative particles which are heavier than the proton, their masses being as high as 5,000 m_e. All these results were also published in Russian in the *C.R. (Doklady) of the Academy of Sciences of the U.S.S.R.*[4] and in more detail in June 1947 [5].

By using a completely different method, S. J. Nikitin of the same laboratory showed that at least three groups of particles with masses larger than that of those commonly observed could be detected in cosmic rays. By measuring the specific ionization of the particles in argon, Nikitin found that the masses of the new particles group around values of 300–500, 700–1,100, 2,000–3,400 m_e. This investigation was also published in February 1947 [6].

As far back as the summer of 1947, by using a large permanent magnet with field strength of 7,500 gauss, we were able to increase considerably the dispersion of our mass-spectrometer. As a result we were able to resolve in greater detail the mass spectrum of the varytrons, and lines with sufficiently distinct edges could be distinguished; these lines yielded mass values of 200, 250, 330, 500–600, 950, 2,200, 3,400, 8,000 and 20,000 electron masses. These results were published in November 1947 [7].

In *Nature* of October 4, 1947, that is, about ten months after the publication of our first papers, Lattes, Powell and Occhialini[8] announced that they had observed eleven meson tracks in a photographic plate with thick emulsion which, after coming to rest in the plate, disintegrated with the emission of a secondary meson. The ratio of the masses of the primary and secondary mesons was estimated to be 2 : 1. Since they were unable to determine the mass of the primary as well as that of the secondary mesons, this result showed that there are at least two types of mesons, one of which is heavier than the other. Proof of the existence of particles heavier than the meson, however, was presented by us at a considerably earlier date, though no reference was made to this by Lattes, Powell and Occhialini.

We wish to emphasize here that our method is a *direct* method of determination of mass based on the measurement of momentum and range of the particles; moreover, at present it is the only method capable of resolving the complex mass spectrum of the cosmic ray particles. The reliability of our method is seen from the fact that the results published by Lattes, Powell and Occhialini confirm our results.

Lattes, Powell and Occhialini determined the mass of the primary meson ('π-meson') on the assumption that the mass of the meson product equalled 200, which thus leads to the value 400. We should like to point out that in view of the large diversity of varytrons which we have observed, such estimations may lead to erroneous results. Up to the present we have detected mesons with the following masses: 110, 140, 200, 250, 300, 350, 450, 550, 680, 850, 1,000, 1,300, 2,500, 3,800, 8,000 and approximately 25,000 [9]. Since Lattes, Powell and Occhialini could not measure directly the mass of the secondary mesons, they could not distinguish between masses of 140 and 200, and therefore the determination of the mass of the primary meson could not be carried out with any degree of certainty.

A note by Rochester and Butler appeared in *Nature* of December 20, 1947 [10], in which two cloud-chamber photographs were reproduced. On the basis of these photographs the authors concluded that there exist particles which are heavier than the usual meson and which decay spontaneously. The two cases observed by Rochester and Butler are obviously insufficient to permit one to draw such fundamental conclusions. However, in view of our work and the work of Lattes, Powell and Occhialini, such a conclusion seems plausible. Rochester and Butler also do not mention our work, although they express their thanks to Prof. P. M. S. Blackett, who, we had thought, would know of our results.

Finally, in *Nature* of April 10, 1948 [11], Powell and Occhialini again discuss their results obtained with thick photographic emulsions, and again no mention was made of our work.

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I FIRST learned of the results of the experiments referred to by Prof. Alichanow and his colleagues in conversations with Dr. A. Rogozinski during a visit to Paris in May 1948. Although I had not, at that time, seen their original papers, I made reference to their work in a lecture which I gave to the French Physical Society during the course of this visit, and