Letters to the Editor

Note on the Interaction of Meson with Nucleon.
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Following the preceding notes\(^1\) we can infer the considerably weak intersection of \(\pi\)-meson with nucleon by the reasons mentioned below. Several arguments for this presumption are described in a separate paper.\(^2\) Here we confine ourselves in the problem of the meson production in cosmic rays, especially referring to a photographic work of Bristol group.\(^3\)

In the first place we take our attention to the fact that the frequency distribution of \(n_e\) reflects the energy spectrum of incident nucleons up to \(n_e = 10\). Such a relation would not take place, if the observed thin tracks were mainly the mesons produced multiply in one nucleon-nucleon collision and the multiplicity of the produced mesons slowly increased with the incident energy. It seems to be plausible that the thin tracks are mesons and protons produced by the plural act in the concerning energy region, \(\lesssim 20\text{ BeV}\). In fact, Heitler and Janossy succeeded to explain this behaviour by their plural production theory.\(^4\)

In spite of the above fact, the mesons are likely produced multiply in higher energy region. A direct evidence is obtained from the Rochester star, which is caused by the incident energy about \(10^{12}\text{ eV} / \text{per nucleon}\).\(^5\) It is a very interesting question in what height of energy the genuine multiple production sets in. Unfortunately, there seems to be so few materials to solve this problem, but we may mention the cloud chamber experiment of Fretter.\(^6\) The energy of the incident nucleons giving rise to the penetrating showers is approximately estimated as \(5\text{ BeV}\) or greater from the absolute frequency.\(^*\) The integral frequency distribution of shower size is represented as nearly \(n^{-3}\) for \(n > A\), where \(n\) is the number of shower particles. This distribution corresponds to neither the energy spectrum of agent nucleons nor the plural production by Heitler and Janossy. In the latter theory much steeper decrease is expected for larger \(n\). This may mean that the genuine multiple production seems to set in for the showers with several or more mesons in heavier nuclei. Thus the multiple process for the interaction of meson with nucleon will be appreciable for greater energy than ever expected.

The energy where the multiple process gets over the single one will give a clue to find the magnitude of the interaction of meson with nucleon. The order of this energy may roughly be estimated by comparing the magnitudes of the matrix elements of the first and the second orders and the density factors of final states. The ratio of the cross sections for both processes is about \(g^2(E/\mu)\rho\), provided that the interaction contains the spatial differentiation of meson field, where \(g\), \(\mu\) and \(\rho\) mean the dimensionless coupling constant, the mass of meson and the ratio of density factors, respectively. If the multiple process overcomes at \(E/\mu \sim 10\), we get \(g^2 \sim 10^{-3}\) to \(10^{-2}\), which is smaller than the factor ten or more than the current value.

The magnitude of \(g^2\) can also be estimated from the ratio of the elastic to the meson producing scatterings for the energy of nucleon about \(g^2(E/\mu)\rho\) times of that for the elastic scattering. This leads to the same order of the magnitude of \(g^2\), considering that about 80% of the nuclear collisions in this energy region are elastic.

These considerations will in detail be discussed lately.

\(^*\) It is supposed that the mixed showers caused by neutral mesons are frequently observed in such a condition that the energy of the agent nucleons is considerably high. The other experiments accompanied by fewer mixed showers may correspond to lower
energy events.
1) Y. Fujimoto et al.: in this issue.
3) See the references of the preceding notes.