Modified Heisenberg's Approach for the Mean Charged Hadron Multiplicity in High Energy Collisions

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The semiempirical formulation of Ghosh et al. for the energy dependence of multiplicity in hadronic collisions has been applied to account for the experimental multiplicity data of $\pi^{\pm}$ p and $K^{\pm}$ p collisions. A remarkable agreement has been found over the entire energy range.

Various theoretical and phenomenological models have been proposed to explain the mechanism of multiparticle production. One of the aspects which allows for a distinction among different models is the dependance of the average charged particle multiplicity on the primary energy E. Different models predict different multiplicity laws [1]. It has been impossible with machine and cosmic ray data up to 10^6 GeV to distinguish unambigously between the different laws. In a recent paper [2] we have proposed a new formulation for the hadronic multiplicity in high energy collisions in the light of Heisenberg's [3] theory and have shown its remarkable agreement with the experimental data in pp collisions over the entire energy range. Here, we present an application of this formulation in the case of $K^{\pm}$ p and $\pi^{\pm}$ p collisions and demonstrate surprising agreement with available experimental data.

Heisenberg proposed a model for multiple meson production based on the basic idea of turbulence. This model has been successfully used to explain many phenomena in hadronic collisions [4].
According to Heisenberg, mesons are produced with the differential intensity $\mathrm{d}I/\mathrm{d}K_0 = a/K_0$, where K_0 is the energy of the meson. From this he obtained the expression

$$\langle n \rangle = \frac{\varepsilon}{m_\pi \ln(\varepsilon/m_\pi)} \dots \qquad (1)$$

for the mean multiplicity, where m_π is the rest mass of a π-meson and ε the total energy available in the c.m. system. If the symmetrical theory of nuclear force is correct on the average, two thirds of the $\langle n \rangle$ π-mesons should be charged and therefore visible. Now our main idea is to make them a suitable choice for the intial colliding system. One can visualize a $K^{\pm}$ p collision in the following way: Since the colliding particles are in excited states, the collision between a Kaon and a proton can be thought of as that between a (Virtual) pion travelling with the velocity of the incident Kaon and a proton at rest. Thus a $K^{\pm}$ p collision effectively reduces to a πp collision, so that less energy will be available for particle production. This type of concept has been applied by Friedlander [5] to estimate the effective target mass in pp interactions. The justification of the concept could be obtained from the works of Friedlander et al [5], who have shown that the observed angles of the recoil protons from 2-prong 9 GeV pp interactions in emulsions yield a fractional energy loss of 14% consistent with a loss of a quasi real pion.

Further we may make a choice about the target. It is quite likely that not the proton as a whole, but rather a ϱ or η-meson may act as the effective target. Thus a $K^{\pm}$ p collision could very reasonably be treated as a $\pi - $p, $\pi - \varrho$ or $\pi - \eta$ collision. Similarily, a $\pi - $p collision may be looked upon as a π p, $\pi\,\varrho$ or $\pi\,\eta$ collision. In each system, since the colliding particles are different, the total available energy in the c.m. system will be different. So the values of multiplicities at a particular energy will depend on the system concerend.

In our analysis the total available energy in the c.m. system (ε) has been calculated by taking the intial colliding system as π p, $\pi\,\varrho$ or $\pi\,\eta$ at different energies, and hence the multiplicities at different energies are obtained for different systems from (1).

Experimental Data and Results

The experimental data for the mean charget multiplicity in $K^{\pm}$ p and $\pi^{\pm}$ p collisions have been collected for the entire energy range available following the paper of Albini et al [6]. The data so collected were then used to test the ideas expressed in this paper. The values of the mean charged multiplicity calculated from (1), considering a $K^{\pm}$ p collision as a πp, $\pi\varrho$ or $\pi\eta$ collision, together with the experimental values have been plottet against the primary energy on a semilog scale (Figure 1). A similar plot is also made for $\pi - $p collisions (Figure 2). The plots reveal some very interesting results.

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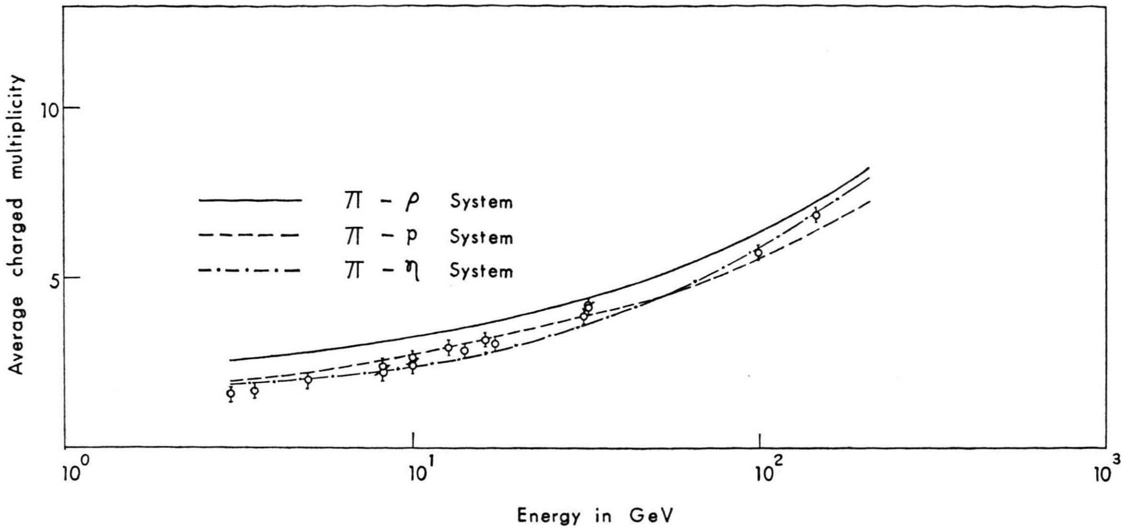

Fig. 1. Plot of average charged multiplicity vs. incoming energy for $K^{\pm}$ p events.

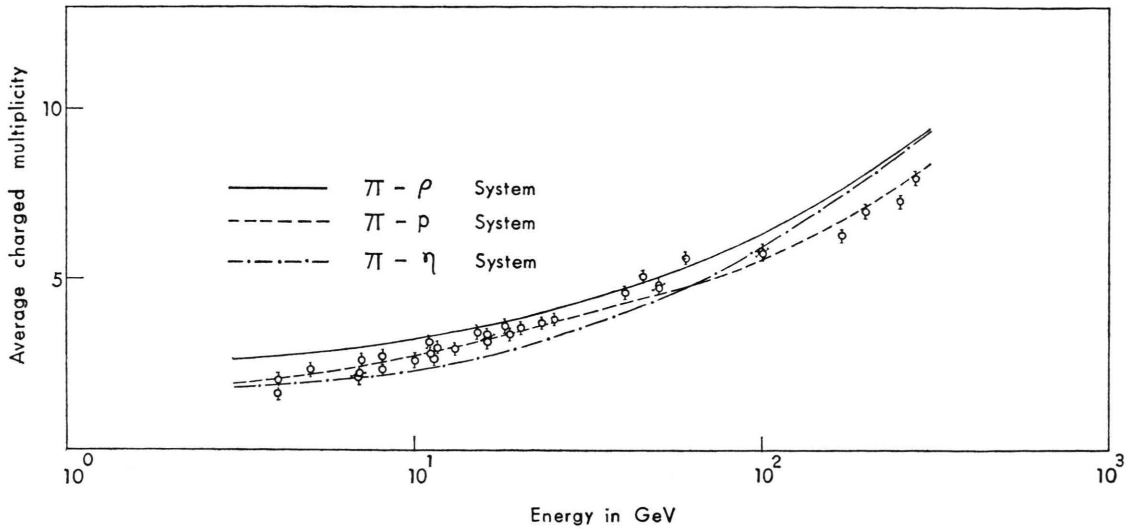

Fig. 2. Plot of average charged multiplicity vs. incoming energy for $\pi^{\pm}$ p events.

From Figs. 1 and 2 it is clear that the π p and $\pi\,\eta$ system can account for the experimental data over the entire energy range, whereas the $\pi - \varrho$ system can't.

From this observation an interesting feature of the interaction process is revealed. With increasing energy the proton as a whole ceases to act as the target and more and more inner structure become effective. It is manifest that our formulation based on Heisenberg's theory is able to account for the energy dependence of the multiplicity in hadronic collisions in the entire range.

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