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PION INTERACTION IN THE FERMI STATISTICAL THEORY

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On the assumption of a resonance π-π interaction the energy spectra are calculated for the π mesons and nucleons produced in inelastic N-N collisions at energy E = 9 Bev. The results of the calculations are compared with experiment.

RECENTLY there have been frequent discussions in the literature of the effect of a possible resonance π-π interaction on calculations made with the statistical theory of the multiple production of particles.[1-8] In several papers it was shown[3,6,7] that for the case of π-N and N-N collisions inclusion of this interaction within the framework of the Fermi theory makes the agreement between the calculated and experimental multiplicity distributions of the stars poorer. On the other hand, Rus'kin[2] and Lebedev and Petrun'kin[5] have been able by including the resonance π-π interaction to get better agreement with experiment in the case of the theoretical momentum distributions of the particles produced in π-p collisions at energies E = 1.0 Bev and E = 1.4 Bev. Statistical calculations must be viewed with caution, however, at energies of the order of 1 Bev, at which there is still very small production of secondary particles. In fact, a more exact analysis[5] has shown that inclusion of the resonance π-π interaction does not explain the experiments as well as Rus'kin[2] believed it did; agreement with experiment can also be obtained without including the π-π interaction, if one carries out all of the statistical calculations in a more correct way.

Since the influence of the resonance interaction of the π mesons increases with increasing energy, we have calculated the momentum spectra of the secondary π mesons and protons for p-p collisions at E = 9 Bev. The results of the calculations are shown in Figs. 1 and 2. In these calculations it was assumed that the spin and isotopic spin of the π-meson isobar are equal to unity, and that its mass μ^* is four times the mass of the π meson. All of the other assumptions and the method of calculation are the same as in reference 3. The experimental data shown in Figs. 1 and 2 are taken from references 9 and 10. The totals of the experimental data for protons are shown in Fig. 2.*

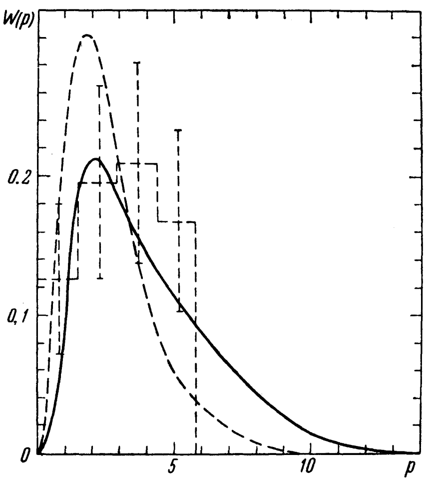

FIG. 1. Momentum distributions of π mesons in the center-of-mass system. The solid curve is that calculated without inclusion of the π-π interaction; the dashed curve is obtained with this interaction included. The dashed histogram shows the experimental data. Values of the momentum p are shown in units μc, where μ is the mass of the π meson.

As can be seen, in both cases the momentum distributions in the theory without the π-π interaction and in the theory with this interaction are nearly the same; but in agreement with the previous papers[3,6] inclusion of the resonance interaction between the π mesons does not on the whole improve the agreement between theory and experiment (cf. reference 11).

*In references 9 and 10, 28 π-meson tracks and 106 proton tracks were analyzed. Figures 1 and 2 show the mean statistical errors. In this connection the total number of protons was taken as 164, since in reference 10 there were 40 protons added owing to various corrections.

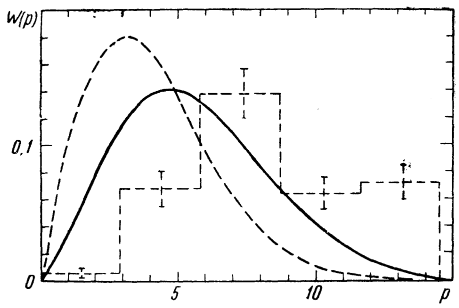

FIG. 2. Momentum distributions of protons in the c. m. s. The notations are the same as in Fig. 1.

This can also be seen from the data in the table, which shows the theoretical and experimental values of the mean momenta of the particles in the center-of-mass system (c. m. s.). In the theory with the π-π interaction included the mean number of particles produced in one act is approximately 20 percent larger than the experimental value.

On the other hand, it has been shown by Eberle and by Zastavenko[1] that without inclusion of the π-π interaction it is hard to explain the experimental data on annihilation. Later this result was confirmed by more exact calculations.[4,7,8]

Thus within the framework of the Fermi statistical theory there are difficulties with a consistent treatment of the resonance π-π interaction.

The question arises again about the resonance interaction of π mesons in a theory which takes peripheral collisions into account (cf. e.g., references 11 and 12). The difference between the multiplicities and momentum spectra of the particles produced in central and peripheral collisions, and the as yet unknown cross sections with which these two types of collisions occur in the experiment, allow us at present to include the π-π interaction without contradiction with experiment. More detailed experimental data and numerical computations are needed, however, to give final conclusions on these questions.

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Mean Momenta $\bar{p}$ (in Bev/c) of Particles in the c. m. s.

Type of Calculation	π mesons	Protons
Without π-π interaction	0.57	0.79
With π-π interaction included	0.42	0.71
Experimental values*	0.4±0.1	1.1±0.3

*The mean dispersion stated is $\bar{p} = [\sum_n N_n(p_n - \bar{p})^2/\sum_m N_m]^{1/2}$.

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225