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TWO-MECHANISM PHENOMENOLOGICAL MODEL AND CHARGED CORRELATIONS TAKING INTO ACCOUNT OF STRANGE PARTICLES IN THE πN-INTERACTIONS AT pc = 40 GEV

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Феноменологическая модель двух механизмов и зарядовые корреляции с учетом странных частиц в π^-N-взаимодействиях при pc = 40 ГэВ

На основе двух механизмов рассматриваются зарядовые распределения и корреляции нейтральных странных и заряженных частиц. Показано, что модель дает хорошее согласие с экспериментальными данными, полученными на двухметровой пропановой камере ОИЯИ, облученной π^--мезонами с импульсом P = 40 ГэВ/с на серпуховском ускорителе.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

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Two-Mechanism Phenomenological Model and Charged Correlations Taking into Account of Strange Particles in the π^-N -interactions at pc=40 GeV

Within the framework of the two-mechanism model we consider the charge distributions and correlations of neutral strange and charged particles.

It is shown that the model provides good agreement with experimental data obtained at the two-meter propane chamber JINR irradiated by the π^--mesons with momenta p = 40 GeV/c at Serpukhov accelerator.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

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In papers[1,2] a phenomenological model has been developed for the multiparticle production in high-energy hadron collisions. It is called the model of two mechanisms (TMP-model). The TMP-model as a concrete phenomenological scheme, has originated in studying the multiparticle production in the framework of coherent-state model[3] and field-theoretical models in the straight-line path approximation[4].

By these models the experiments performed at two-meter propane chamber at pC = 40 GeV were described. The model predictions are in good agreement both with the Serpukhov experiments[5] and with the FNAL[6] and ISR[7] experiments on multiparticle production.

The main point of the TMP-model is the hypothesis on existance of two mechanisms of the production:

a) There exist leading particles which dissociate (with the isospin local conservation);

b) In a central region there occurs noncorrelated production of hadron associations (or clusters) decaying then into pions and kaons. The average numbers of these associations are assumed to be independent of the type of colliding particles (pp , πp , πn , Kp ,...).

To describe the experimental data at p_ℓ = 40 GeV it is sufficient to consider three types of associations σ, ω, Λ with isospin I =0, produced independently by the Poisson law. The consideration may be limited by the following main decay channels:

$$\sigma \to \pi^+\pi^-;\ \pi^0\pi^0\ ,$$
$$\omega \to \pi^+\pi^-\pi^0\ ,$$
$$\Lambda \to K^+K^-;\ K^0\bar{K}^0\ .$$

The assumption on I =0 of the associations gives

$$\langle n_\pm \rangle = 2\langle n_0 \rangle\ ,$$
$$\langle m_\pm \rangle = \langle m_0 \rangle\ ,$$

where $\langle n_\pm \rangle$, $\langle n_0 \rangle$, $\langle m_\pm \rangle$, $\langle m_0 \rangle$ are mean numbers of pairs $\pi^+\pi^-$, $\pi^0\pi^0$, K^+K^-, $K^0\bar{K}^0$ respectively.

For the channels of dissociation of leading particles it is sufficient to take the following ones:

For pion:

1. $\pi^- \to \pi^-$
2. $\pi^- \to 2\pi^-\pi^+$ (1)
3. $\pi^- \to 2\pi^0\pi^-$

For nucleon

1. $N \to N$
2. $N \to N\pi^0$
3. $N \to N'\pi^\pm$ (2)
4. $N \to \Lambda^0 K^{+,0}$
5. $N \to \Sigma^0 K^{+,0}$
6. $N \to \Sigma^{+,-} K^{0,+}$

The probability of an i-th channel of dissociation is put to be the same for proton and neutron. Denoting the probability of the first dissociation channel of nucleon by α, the second by β, the fourth by γ, the fifth by δ, we obtain, from the isospin local conservation, that the probability of the third channel is 2β, of the sixth is 2δ. The probabilities of the nucleon dissociation obey the relation

$$\alpha + 3\beta + \gamma + 3\delta = 1 \tag{3}$$

The sum of the probabilities of the first and third channels of the pion dissociation is denoted by μ, the probability of the second channel by ν. Then one has that

$$\mu + \nu = 1$$

Keeping the above assumptions one can easily see that the probabilities: $n_{\pm}$ of $\pi^+\pi^-$ pairs, n_0 of the $\pi^0\pi^0$ pairs, n_3 of the triplets $\pi^+\pi^-\pi^0$, $m_{\pm}$ and m_0 of the K^+K^- and $K^0\bar{K}^0$ respectively, for the given channels of dissociation are as follows:

$$W_{\substack{n_{\pm}, n_0, m_{\pm}, m_0 \\ \pi^- \to \dots \\ N \to \dots}} = W^{D}_{\pi^- \to \dots} \cdot W^{D}_{N \to \dots} \cdot P_{n_{\pm}}(\langle n_{\pm} \rangle) \times$$

$$\times P_{n_0}(\langle n_0 \rangle) \cdot P_{n_3}(\langle n_3 \rangle) \cdot P_{m_{\pm}}(\langle m_{\pm} \rangle) \cdot P_{m_0}(\langle m_0 \rangle), \tag{4}$$

where $W^{D}_{N \to \dots}$ takes the values α, β, 2β, ..., $W^{D}_{\pi^- \to \pi^-} + W^{D}_{\pi^- \to 2\pi^-\pi^+} = \mu$, etc.

where n_{s0} equals the number K^0's, Σ^0's and Λ^0's (but not $\bar{K}^0$'s, $\bar{\Sigma}^0$'s).

Note that $\langle n_{s0}\rangle^{\pi p}_{n_c} = Const$ and does not depend on n_c, and $\langle n_{s0}\rangle^{\pi^- n}_{n_c}$ reaches a Const. at sufficiently large n_c.

It should be accentuated that here we have made the most simple assumptions on the channels of the dissociations and on independent production of hadron associations. The fit of experimental data reveals that the above assumptions are sufficient for describing the πN- interactions at p = = 40 GeV/c.

At higher energies, generally speaking, it is necessary to take into account other channels as well. For instance, there exists a possibility of production of the hadron association decaying into three particles $K\bar{K}\pi$, and so on.

Apparantly, the probabilities of their production at energies under consideration are small. We stress that taking into account of such triplets, that is necessary to do at higher energies[10], leads to the positive correlations $\langle n_{s0}\rangle_{n_c} = f(n_c)$.

In this paper we have exploited the photographs obtained from the two-meter propane bubble chamber irradiated with 40 GeV/c π^--mesons at the Serpukhov accelerator (for details concerning selection, separation of interactions and analysis of the data see ref.[8]).

Out of the three- and five-prong $\pi^- n$ -events there is eliminated the admixture of coherent events due to the pion production on carbon. The cross sections were taken to be

As is shown in paper [2] devoted to the description of preliminary data on $\pi^- N$-scattering with an account of strange particles from eq. (4) one can easily obtain the distributions over multiplicity of charged particles

$$W_{n_c}(\pi^- p) = \mu \cdot P_{\frac{n_c-2}{2}}(a) + \nu \cdot P_{\frac{n_c-4}{2}}(a)$$

$$W_{n_c}(\pi^- n) = f_1 \cdot P_{\frac{n_c-1}{2}}(a) + f_2 \cdot P_{\frac{n_c-3}{2}}(a) + f_3 \cdot P_{\frac{n_c-5}{2}}(a), \quad (5)$$

where there are used the following notations

$$P_n(A) = e^{-A} \cdot \frac{A^n}{n!}$$

$$a = \langle n_\pm \rangle + \langle n_3 \rangle + \langle m_\pm \rangle$$

$$f_1 = \mu\,(1 - 2\beta - 2\delta)$$

$$f_2 = \mu \cdot (2\beta + 2\delta) + \nu \cdot (1 - 2\beta - 2\delta)$$

$$f_3 = \nu \cdot (2\beta + 2\delta).$$

The correlations of neutral strange and charged particles are of the form

$$\langle n_{s0} \rangle_{n_c}^{\pi^- p} = \langle m_\pm \rangle + 1 - \alpha - 3\beta \qquad \text{(6a)}$$

$$\langle n_{s0} \rangle_{n_c}^{\pi^- n} = \langle m_\pm \rangle + (2\gamma + 2\delta) \times$$

$$\times \frac{\mu + \nu \cdot \frac{n_c - 1}{2a}}{f_1 + f_2 \cdot \frac{n_c - 1}{2a} + f_3 \cdot \frac{(n_c - 1)(n_c - 3)}{4a^2}} \qquad \text{(6b)}$$

$\sigma_3^{coh.} = 4,4$ mb and $\sigma_5^{coh.} = 0.3$ mb [5].

From one-prong events the admixture of elastic - interactions and coherent events $\pi^- C \to \pi^- \pi^- \pi^0 C$ is not completely eliminated because of our experimental conditions.

In two-prong $\pi^- p$-interactions the elastic events were separated according to criteria from [9], obtained on the basis of methodical distributions. After that separation of events there remained 8278 $\pi^- p$ - and 2764 $\pi^- n$ -interactions, which we reffered to the inelastic interactions of π^--meson with free and quasi-free nucleons.

The parameters of the given model are determined by simultaneous fit of the charged distributions [5] and of the dependence $\langle n_{\pi^0} \rangle_{n_c}^{\pi N} = f(n_c)$ [6] (see fig. 1 and 2). The agreement between the experiments and the formulas is good: $\chi^2/N = 1.8$, where N is the number of degrees of freedom.

After the total separation of the three-prong events we obtain $\chi^2/N = 1.2$ but the change of parameters were negligible. The values of parameters are found to be as follows: the average number of meson combinations $\pi^+\pi^-$, K^+K^-, $\pi^+\pi^-\pi^0$

$$a = 1,76 \pm 0,04$$

the coefficient of the charge exchange

$$K_{ce} = 0,35 \pm 0,05$$

the probabilities of nucleon and pion dissociation

$$\alpha = 0,44 \pm 0,09$$

$$\beta = 0,16 \pm 0,05$$

$$\delta = 0,01 \pm 0,05$$

$$\mu = 0,92 \pm 0,06 .$$

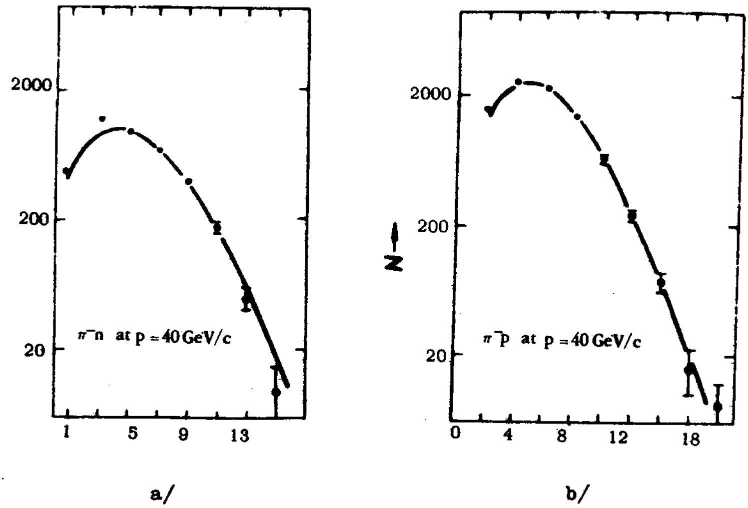
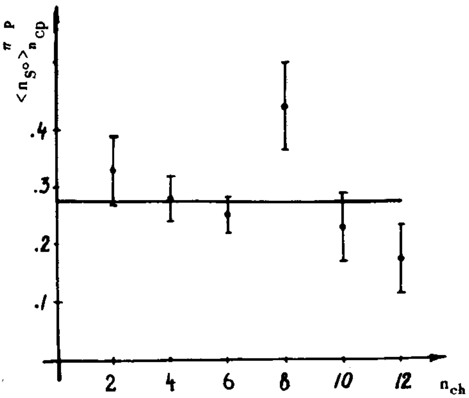
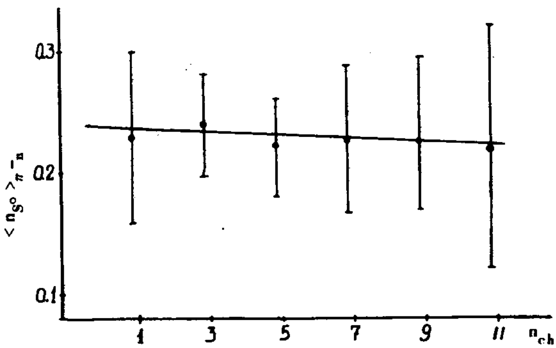

2000
200
20
π⁻n at p = 40 GeV/c
1
5
9
13
a/
2000
200
20
N
π⁻p at p = 40 GeV/c
0
4
8
12
18
b/

Fig.1 a), b)



a/



b/

Fig.2 a), b)

The average number of strange particles

$$\langle n_{sc} \rangle^{\pi^- p} = 0,27 \pm 0,02$$

$$\langle n_{sc} \rangle^{\pi^- n} = 0,23 \pm 0,02 .$$

The results obtained do not contradict the results of the paper/2/ devoted to the description of preliminary data on πN-scattering taking into account strange particles.

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