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VECTOR MESON PRODUCTION AT HIGH ENERGY AND THE QUARK MODEL

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A comparison of the predictions of the quark model with existing experimental data on the vector meson production is presented.

In this paper we compare some of the predictions of the quark model, concerning the production of the vector mesons at high energy, with the available experimental data.

The quark model of high energy reactions gives the following relations between the different vector meson production processes [1]:

$$\frac{d\sigma_{ik}}{dt}(\pi^- p \to \varrho^0 n) + \frac{d\varrho_{ik}}{dt}(\pi^+ n \to \omega^0 p)$$

$$= \frac{d\sigma_{ik}}{dt}(K^+ n \to K^{*0} p) + \frac{d\sigma_{ik}}{dt}(K^- p \to \overline{K^{*0}} n) \ldots \tag{1}$$

where assumption was made that Φ^0 production in the processes $\pi^- p \to \Phi^0 n$ is negligible and

$$\frac{d\sigma_{ik}}{dt} = \frac{d\sigma}{dt}\varrho_{ik}$$

Here ϱ_{ik} denotes the density matrix element for the vector meson. A particular case of the relation (1) is:

$$\sigma(\pi^- p \to \varrho^0 n) + \sigma(\pi^+ n \to \omega p) = \sigma(K^- p \to \overline{K^{*0}} n) + \sigma(K^+ n \to K^{*0} p) \ldots \tag{2}$$

The cross-sections for the ϱ mesons production are plotted in Fig. 1*a*, as a function of incoming lab momentum [2].

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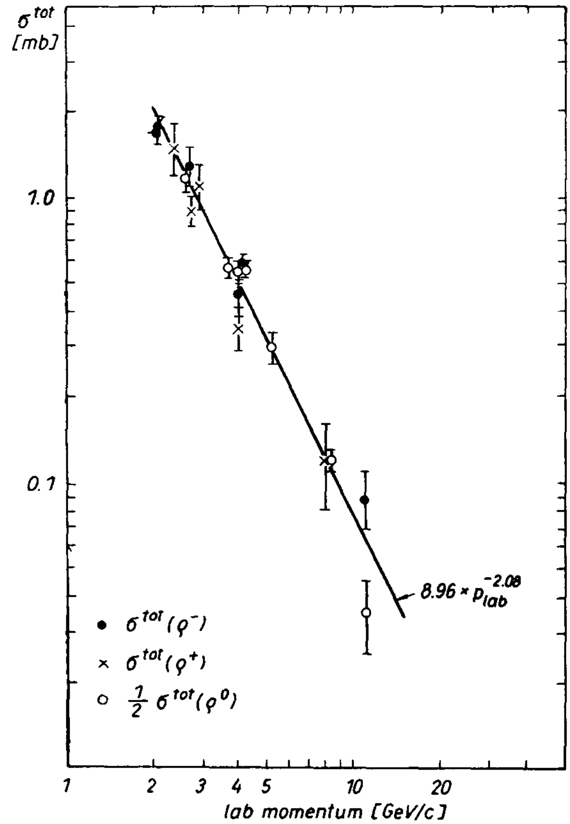


Fig. 1*a*. Cross-section for ϱ production in the processes $\pi^{\pm}p \to \varrho^{\pm}p$; $\pi^{-}p \to \varrho^{0}n$, *vs.* momentum. Solid line is the fit obtained with the help of least squares method, using the slope $n = 2.08$

It is seen that the well-known [3] momentum dependence:

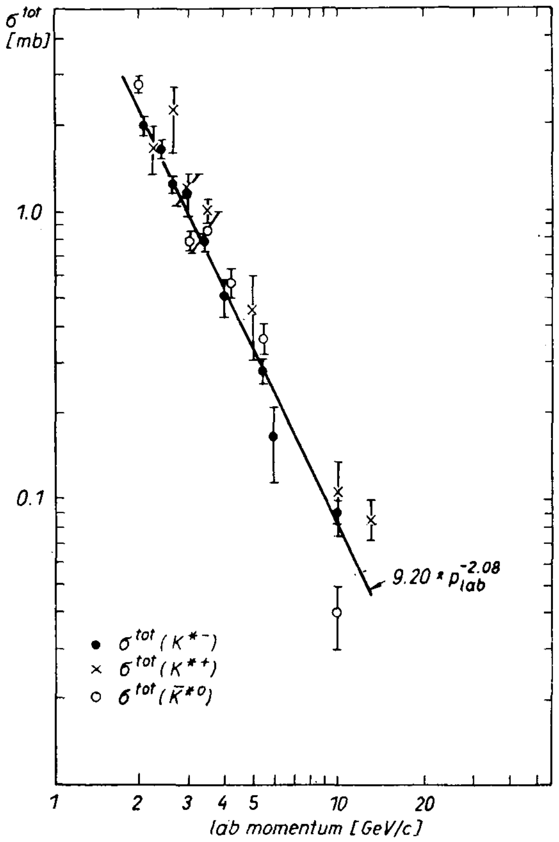
$$\sigma^{\text{tot}} = K_0 \times p_{\text{lab}}^{-n} \tag{3}$$

is satisfied in the considered momentum range. One observes also the equality:

$$\sigma^{\text{tot}}(\varrho^{+}) \approx \sigma^{\text{tot}}(\varrho^{-}) \approx \frac{1}{2}\,\sigma^{\text{tot}}(\varrho^{0}) \tag{4}$$

where $\sigma^{\text{tot}}(\varrho^{+})$, $\sigma^{\text{tot}}(\varrho^{-})$ and $\sigma^{\text{tot}}(\varrho^{0})$ stands for the cross-section for production of ϱ^{+}, ϱ^{-} and ϱ^{0} respectively. Equality (4) is consistent with the pure isospin 1 exchange in the production processes.

The cross-section for K^{*} production is plotted in Fig. 1*b* [4]. There is no significant difference between the four processes leading to the K^{*} production. Comparing Figs 1*a* and 1*b* it is seen, that the charged ϱ production is significantly smaller than K^{*} production. The cross-section for ω^{0} production is plotted in Fig. 1*c* [5].



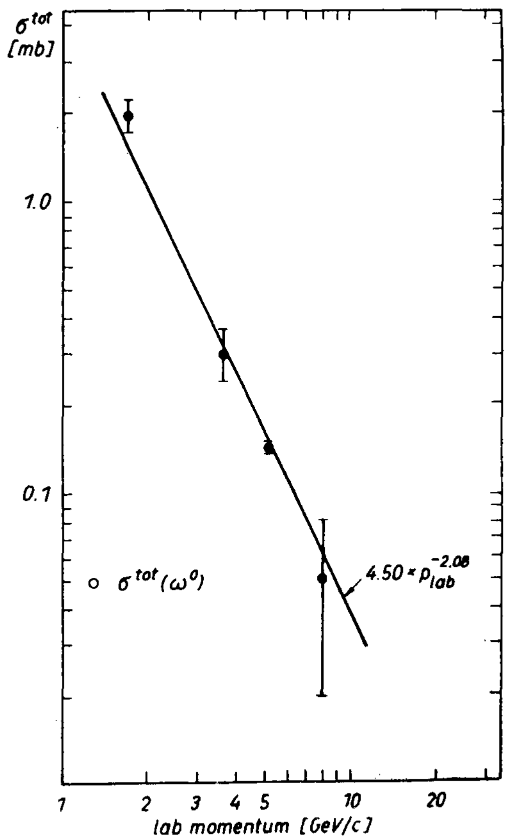


Fig. 1*b*. Cross-section for K^* production in the processes $K^-p \rightarrow K^{*-}p$; $K^+p \rightarrow K^{*+}p$; $K^-p \rightarrow K^{-*0}n$ *vs.* momentum. Solid line is the fit obtained with the help of least squares method, using the slope $n = 2.08$

Fig. 1*c*. Cross-section for the ω^0 — production in the process $\pi^+n \rightarrow \omega^0p$. Solid line is the fit obtained with the help of least squares method, using $n = 2.08$

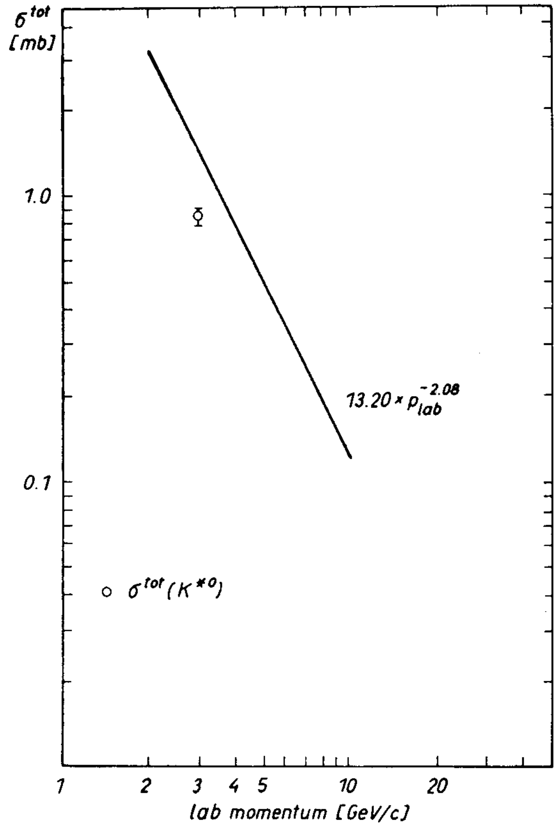


Fig. 2. Cross-section for K^{*0} production in the process $K^+n \to K^{*0}p$. Solid line is the prediction

In Fig. 2 the solid line is a prediction for the $K^+n \to K^{*0}p$ cross-section derived from the relation (2) and the experimental data as given in Fig. 1*a*, 1*b* and 1*c*.

The procedure we used to obtain this prediction was to fit the ϱ^0, K^{*0} and ω^0 cross-sections in the form (3), assuming the common exponent n for all of them. The results of the fit are given in Table I.

From the values given in Table I and the sum rule (2) we get for $K^+n \to K^{*0}p$: $K_0 = 13.20 \pm 0.90$, $n = -2.08 \pm 0.04$. These results have been used in preparing Fig. 2.

TABLE I

$$\sigma^{\text{tot}} = K_0 p_{\text{lab}}^{-n}$$

	K_0	n
$\sigma(\pi^- p \to \varrho^0 n)$	17.90 ± 0.80	2.08 ± 0.04
$\sigma(K^- p \to \bar{K}^{xo} n)$	9.20 ± 0.40	2.08 ± 0.04
$\sigma(\pi^+ n \to \omega^0 p)$	4.50 ± 0.20	2.08 ± 0.04

It is seen from Fig. 2 that the quark model prediction does not agree with the experimental point at 3.0 GeV/c, the predicted value being 132 μb while the experimental cross-section equals 84 ± 6 μb. We conclude that the quark model sum rule is badly violated by the existing experimental data.[1]

We think that this violation is related to the previously observed discrepancy between the quark model prediction and the experimental data on the photoproduction of pions.[2]

Finally we would like to make a few comments on charge dK^* meson production. There is one fundamental theoretical feature of these processes, which makes the analysis rather difficult. Charged K^* meson production is the only case (among the processes considered in this paper) where the elastic interaction of the strange quark plays a role. This can be easily understood, since the elastic quark-quark amplitude

$$\lambda p \to \lambda p$$

describes $\Delta I = 0$ exchange (the isospin I of the λ-quark is 0). Therefore it cannot enter the neutral K^* production which depends only on charge exchange amplitudes.

It follows from these considerations, that in the framework of the quark model, there exists a fundamental difference between charged K^* production and other processes considered in this paper. It is rather encouraging to find that also experimentally these processes are different from others. In particular one observes a strong $\Delta I = 0$ exchange component in charged K^* meson production processes. Unfortunately very little is known about the elastic ΛN interactions at high energy and therefore it is rather difficult to discuss these reactions in more details.

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[1] The assumption of the common exponent n for all processes entering (2) is only approximately valid. The best fit of the formula (3) to the experimental data gives lower value for n for ϱ production then for $\overline{K}^{*0}$ and ω^0 production. We have checked that this does not influence our conclusion.

[2] This problem was also discussed in Ref. [6].

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