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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

ЕФИ-485(28)-81

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ON STRUCTURE FUNCTIONS OF VECTOR MESONS IN $e^+e^- \to VX$ INCLUSIVE PROCESS IN RELATIVISTIC QUARK MODEL

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1. The study of hadron structure functions in the framework of quantum chromodynamics is at present of great interest. Since QCD determines the hard part of processes rather reliably then, comparing the calculation results with the experiment, one can judge of the validity of the models describing the soft part, i.e. the quark-hadron transition in fact.

The purpose of the present work is to study the vector meson inclusive production in the process

$$e^+e^- \to V + X \qquad (1)$$

in deep inelastic region when $x = \frac{q^2}{2Pq} \sim 1$ (4-momenta are shown in Figs 1 and 2).

Certain assumptions will be made concerning the form of the $q\bar{q} \to V$ transition amplitude and in the framework of these assumptions the dependence of structure functions and hence the dependence of other physical values determined by them on the vecton transverse momentum $P_\perp$ relative to the jet axis will be found. The latter is determined by the direction of momenta of the quark-antiquark pair produced by a virtual photon.

2. Since the process (1) hard part is well described in the ~~work [1] here~~ we ~~shall not~~ discuss it in details. As in

the mentioned work, the result of the condition $x-1 \ll 1$ is that the gluon producing the quark-antiquark pair is strongly virtual

$$p_g^2 \sim \frac{m^2 + p_\perp^2}{x-1}$$

(m is the quark mass; to make it simpler all quark masses are considered equal), and the constant α_s is small which allows to limit oursélves with the one-gluon exchange diagrams.

It is convenient to consider the $q\bar{q}$ -pair transition to vector meson in the noncovariant perturbation theory [2] where the Fig. 3 type diagrams die out with the rise of P . This allows to put down the $q\bar{q} \to V$ transition vertex function in the form $f(M^2)$ where $M^2=(p_1+p_2)^2$ is the invariant mass of the quark-antiquark pair. Let's take the function $f(M^2)$ in the form

$$f(M^2) = N(M^2 - m_v^2) \exp\left[-\frac{M^2}{m_v^2}\right] \qquad (2)$$

(N is the normalization factor, m_v is the vecton mass) corresponding to the oscillator potential (see e.g. [2,3]).

Having thus determined the vertex function let's put down the transition $q\bar{q} \to V$ amplitude in the form

$$\frac{1}{2M^2} f(M^2)\, \bar{u}(-p_2)(\hat{p}_1 + \hat{p}_2 - M)\gamma_\rho(\hat{p}_1 + \hat{p}_2 + M)u(p_1) \qquad (3)$$

As shown in [4] such an amplitude ensures the correct quantum numbers of the vecton, i.e. here the quarks are in the S-wave state with a spin 1.

Using the amplitude (3) and the standard Feynman QCD-rules it is possible to calculate on the basis of the Fig. 2a and 2b diagrams the introduced in [1] hadron tensor

$$t_{\mu\nu}^{\alpha\beta}(P_\perp^2) = (2\pi)^3 \Sigma \langle P, P_1, P_x | J_\mu^\alpha | 0 \rangle^* \langle P, P_1, P_x | J_\nu^\beta | 0 \rangle \delta(q - P - P_x),$$

and hence the structure functions $F_i(P_\perp^2)$, determining it, as well. Here we make use of the following parametrization of the quark P_1 and P_2 momenta:

$$\vec{P}_1 = \alpha \vec{P} + \vec{K}_\perp$$
$$\vec{P}_2 = (1-\alpha)\vec{P} - \vec{K}_\perp \,, \qquad (4)$$

where $\vec{P}\vec{K}_\perp = 0$ and $P_1^2 = P_2^2 = m^2$. At such parametrization $M^2 = \frac{m^2 + K_\perp^2}{\alpha(1-\alpha)}$ and the integration by P_1 and P_2 is reduced to the integration by M^2 and α . The integrals containing $\exp\left[-\frac{M^2}{m^2}\right]$ can be calculated, considering the quarks in the process (1) hard part are current ones and have the mass $m \ll m_v$.

Thus, for the structure functions F_1 and F_3 connected with other six by the Callan-Gross type relations [1] and determining [5] the vecton helicity density matrix we obtain the following expressions:

$$F_1 = A \frac{m_v^8}{P_\perp^8}(x-1)^2 \ell n^2 \frac{m^2}{m_v^2}$$
$$F_3 = A \frac{m_v^8}{P_\perp^8}(x-1)^2 \left[0{,}3\, \ell n^2 \frac{m^2}{m_v^2} - \frac{P_\perp^2}{m_v^2}\right] \qquad (5)$$

The constant A includes the numerical factors arising due to summarizing by the quark colours and flavours, the coupling constants and the function $f(M^2)$ normalization factor N

The obtained expressions for the structure functions allow to immediately calculate the density matrix of the produced vecton:

In particular, at $P_\perp^2 \lesssim m_v^2$ we have $\rho_{00} = 0.26$, and at $P_\perp^2 \gg m_v^2 \ell n^2 \frac{m^2}{m_v^2}$ $\rho_{00} = 1$, i.e. the vecton is polarized transversly.

Thus, the account of quark motion in the vecton leads to the decrease of longitudinal polarization at small $P_\perp^2$. Another result of this is that the vecton turns out transversly polarized at $P_\perp^2 \gg m_v^2 \ell n^2 \frac{m^2}{m_v^2}$ i.e. at considerably larger transverse momenta. With the account of these corrections the results obtained in the work [1] and, particularly, different forms of the angular distribution of products of the vecton decay into two pions at various $P_\perp^2$, remain valid:

$$W(\theta') = \frac{3}{4\pi} 0{,}2\left(1 + \sin^2\theta'\right) \qquad \text{at } P_\perp^2 \sim m_v^2$$

$$W(\theta') = \frac{3}{4\pi} \cos^2\theta' \qquad \text{at } P_\perp^2 \gg m_v^2 \ell n^2 \frac{m^2}{m_v^2}$$

where θ' is the π-meson exit angle relative to $\vec{P}$ in the vecton rest system.

In conclusion the author expresses his thanks to S.G.Matinyan, Yu.G.Shakhnazarian, N.L.Ter-Isahakian and S.V.Yesaybekian for constant interest in the work.

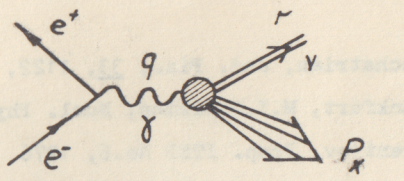

Fig. 1

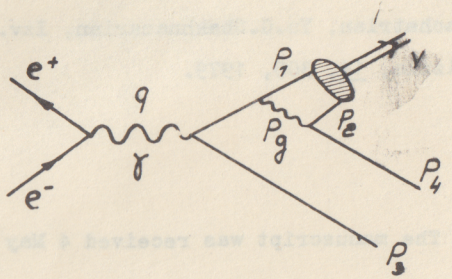

Fig. 2a

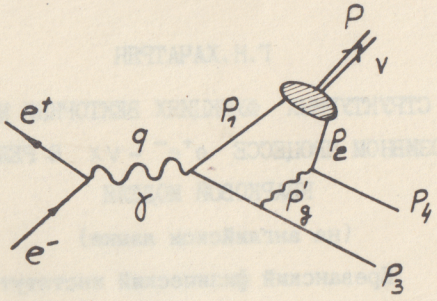

Fig. 2b

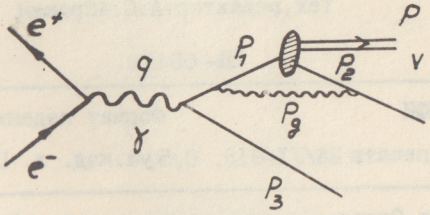

Fig. 3

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The manuscript was received 4 May 1981

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О СТРУКТУРНЫХ ФУНКЦИЯХ ВЕКТОРНЫХ МЕЗОНОВ В ИНКЛЮЗИВНОМ ПРОЦЕССЕ $e^+e^- - VX$ В РЕЛЯТИВИСТСКОЙ КВАРКОВОЙ МОДЕЛИ

(на английском языке)

Ереванский физический институт

Тех,редактор А.С.Абрамян

Заказ 401 ВФ-05402 Тираж 299

Препринт ЕФИ Формат издания 60x84/16

Подписано к печати 24/VI-81г. 0,5 уч.изд. л. Ц. 4 к.

Издано Отделом научно-технической информации Ереванского физического института, Ереван-36,пер.Маркаряна 2