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THE SPECTATOR MODEL OF D-MESON NONLEPTONIC DECAYS AND THE EXPERIMENT

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А.Ю.ХОДЖАМИРЯН

МОДЕЛЬ СПЕКТЕЙТОРА НЕЛЕПТОННЫХ РАСПАДОВ D -МЕЗОНОВ И ЭКСПЕРИМЕНТ

Новые данные по квазидвухчастичным нелептонным распадам $D \to K\rho$, $K^*\pi$ обсуждаются с точки зрения модели, в которой доминируют кварковые диаграммы распада c -кварка (модель спектейтора). Продемонстрировано качественное и количественное согласие этой модели с указанными экспериментальными данными в случае, когда параметры эффективного гамильтониана нелептонного взаимодействия извлекаются непосредственно из эксперимента.

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THE SPECTATOR MODEL OF D-MESON NONLEPTONIC DECAYS AND THE EXPERIMENT

The recent data on quasi-two-body weak nonleptonic decays $\mathcal{D} \to K\rho, K^*\pi$ are discussed in terms of the simple model where c -quark decay diagrams dominate (the spectator model). The agreement of this model with experimental situation is demonstrated in the case when the parameters of the effective Hamiltonian are extracted directly from experimental inputs.

Yerevan Physics Institute

Yerevan 1981

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THE SPECTATOR MODEL OF D-MESON NONLEPTONIC DECAYS AND THE EXPERIMENT

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Recently the new results on D-meson weak nonleptonic decays have been obtained in MARK II experiment [1] at SPEAR e^+e^- -storage rings. The $\mathcal{D} \to K\pi\pi$ Dalitz plots have been studied and new quasi-two-body decay modes $\mathcal{D} \to K\rho$ and $\mathcal{D} \to K^*\pi$ ($\mathcal{D} \to VP$) have been observed.

The aim of this note is to analyze these data from the point of view of the D-meson decays quark mechanism. This subject is now widely discussed in connection with the observed sharp difference between $\mathcal{D}^+$ and $\mathcal{D}^o$ mean lifetimes (see e.g. [1] and references therein).

First of all let us emphasize that the discovery of $\mathcal{D} \to VP$ modes at last removes the drastic contradiction noticed earlier [2, 3] between the relations

$$\frac{\tau(\mathcal{D}^+)}{\tau(\mathcal{D}^o)} BR(\mathcal{D}^o \to K^-(\pi^+\pi^o)_s) = BR(\mathcal{D}^+ \to \bar{K}^o(\pi^+\pi^o)_s) = \frac{1}{4} BR(\mathcal{D}^+ \to K^-\pi^+\pi^+) \qquad (1)$$

for the branching ratios into symmetrical three-body states $\mathcal{D} \to K(\pi\pi)_s$ and the experimental numbers [1]: $BR(\mathcal{D}^o \to K^-\pi^+\pi^o) = (8.5 \pm 3.2)\%$; $BR(\mathcal{D}^+ \to \bar{K}^o\pi^+\pi^o) = (12.9 \pm 8.4)\%$; $BR(\mathcal{D}^+ \to K^-\pi^+\pi^+) = (6.3 \pm 1.5)\%$ and $\tau(\mathcal{D}^+)/\tau(\mathcal{D}^o) >> 1$.

Really, according to Ref. [1] the main contribution into the final state

$\mathcal{D}^0 \to K^-\pi^+\pi^0$ comes from $\mathcal{D}^0 \to K^-\rho^+$ (85%), $\mathcal{D}^0 \to \bar{K}^{*0}\pi^0$ (11%) and $\mathcal{D}^0 \to K^{*-}\pi^+$ (7%) modes, while the nonresonant mode $\mathcal{D}^+ \to K^-(\pi^+\pi^0)_s$ is absent within the accumulated statistics. (The deviation of branching ratios sum from 100% [1] is due to small interference between the corresponding amplitudes). Similarly [1] the sizable part $\gtrsim$(15-40)% of $\mathcal{D}^+ \to \bar{K}^0\pi^+\pi^0$ decay goes through the $\mathcal{D}^+ \to \bar{K}^0\rho^+$ resonant mode. At the same time the $\mathcal{D}^+ \to K^-\pi^+\pi^+$ decay has mostly nonresonant character, the $\mathcal{D}^+ \to \bar{K}^{*0}\pi^+$ contribution being no more than 40%.

These results in fact mean that the relations (1) already don't contradict the experiment. Nevertheless precise symmetrical three-body branching ratios are still needed to establish the quantitative agreement.

Recall that the relations (1) are quite model-independent and follow from the general isospin structure $\Delta T = 1$ of the weak nonleptonic charm change interaction. The available experimental data are yet insufficient to check the rest of such general relations following from $\Delta T = 1$, $\Delta U = 1$ and other selection rules. *)

*) The only exception is the familiar relation following from $\Delta U = 1$ selection rules for the Cabibbo suppressed decays [4,5]

$$BR(\mathcal{D}^0 \to \pi^+\pi^-) = BR(\mathcal{D}^0 \to K^+K^-) = tg^2\theta_c\, BR(\mathcal{D}^0 \to K^-\pi^+)$$

$(tg^2\theta_c \simeq 0.05)$, which is to be compared with [1]:

$$BR(\mathcal{D}^0 \to \pi^+\pi^-)/BR(\mathcal{D}^0 \to K^-\pi^+) = 0.033 \pm 0.015$$

$$BR(\mathcal{D}^0 \to K^+K^-)/BR(\mathcal{D}^0 \to K^-\pi^+) = 0.113 \pm 0.030.$$

To our mind, these experimental numbers are not precise enough to indicate the deviation from $\Delta U = 1$ (e.g. [6] due to the six-quark mixing angles) since within experimental errors such deviation may be well understood as a usual SU(3)-breaking.

The more detailed analysis of nonleptonic decays at the level of quark diagrams leads [3] to a lot of additional model-dependent relations which we now wish to discuss.

The understanding of D-meson decay quark mechanism has undergone a considerable evolution over the last time.

The initial simplified consideration [7,8] dealing with the c-quark decay as an asymptotically free process and resulting in a parton-like equality of $\tau(\mathcal{D}^+)$ and $\tau(\mathcal{D}^0)$ has turned out to be too crude. The observed difference between $\tau(\mathcal{D}^+)$ and $\tau(\mathcal{D}^0)$ indicates that the typical distances in the decay of c-quark (where the energy of order of $m_c \sim 1.5$ GeV is divided among three originating light quarks) are not small enough to consider this process as an asymptotically free one.

It seems that the QCD leading log approximation [8] for the coefficients $C_\pm$ of the effective nonleptonic Hamiltonian:

$$H_{eff} = \frac{G}{\sqrt{2}}\cos^2\theta_c \frac{1}{2}\sum_{\pm} C_\pm \left\{(\bar{s}c)(\bar{u}d) \pm (\bar{u}c)(\bar{s}d)\right\} \tag{2}$$

$$C_+ \simeq 0.7 \quad , \quad C_- \simeq 1.9 \tag{3}$$

is also incorrect. As it is already known, the substitution of these values into the relation [3,9] :

$$BR\,(\mathcal{D}^0 \to \bar{K}^0 \pi^0) = \frac{\delta^2}{2} BR\,(\mathcal{D}^0 \to K^- \pi^+) \tag{4}$$

where

$$\delta = \frac{2 - c_-/c_+}{2 + c_-/c_+} \tag{5}$$

leads to disagreement with the experiment [1]:

$$BR\,(\mathcal{D}^0 \to \bar{K}^0 \pi^0) = (2.1 \pm 0.9)\% \qquad (6)$$
$$BR\,(\mathcal{D}^0 \to K^- \pi^+) = (2.8 \pm 0.5)\%$$

Recall that (4) as well as a great number of other relations between the amplitudes of nonleptonic decays (see e.g. [3]) emerges in the so-called spectator model where decay type quark diagrams (Fig.1) dominate while the annihilation type diagrams (Fig.2) are consistently neglected. The last diagrams are suppressed in widths by the familiar (V-A) factors of $(\mu/m_c)^4$ where μ is of order of light quark mass.

Recently an alternative annihilation mechanism decreasing the $\mathcal{D}^0$-lifetime has been suggested [11], where the V-A suppression is removed due to gluon radiation by the initial $c\bar{u}$ state. The assumption of dominance of such diagrams explains both the $\tau(\mathcal{D}^+)/\tau(\mathcal{D}^0)$ ratio and the violatic of (4). Note however that the perturbative calculations indicating certain enhancement of these gluon annihilation diagrams are, strictly speaking, unreliable since the gluon radiation process takes place at essentially large distances. In fact a sizable valence gluon component in the wave function of D-meson is needed [12] to achieve desired dominance of the annihilation diagrams. This last conjecture seems quite artificial since until now there have been no indications of such deviation from the valence quark model for any of the known pseudoscalar mesons.

Realizing that the naive spectator model is inapplicable and at the same time the alternative annihilation model is not well-founded, one can form a following pessimistic view of the situation. The pattern of nonleptonic charm decays is complicated being totally controlled by large distance dynamics. No simple representation of these processes in terms of quark diagrams is possible.

Furthermore, the situation may be even more difficult since the final state interaction effects ($K\pi$ rescattering) may contribute as it was noted in Ref.[13] .

Nevertheless in our previous paper [14] it was demonstrated that within the framework of simple spectator model and valence quark approximation one can naturally explain all discrepancies between the naive model and the experiment.

In the remaining part of this paper we shall briefly recall the main arguments presented in [14] and will realize that the model developed there also agrees with the new data [1] . Finally, several numerical mistakes in Ref.[14] will be corrected, which however did not influence on the final (rather qualitative) results of that paper.

According to [14] the total nonleptonic width of D-meson is not determined by an asymptotically free c -quark decay, but is formed as a sum of partial widths of separate decay modes. Every exclusive decay proceeds at essentially large distances. Nevertheless to every such process there corresponds [14] a definite set of quark diagrams of spectator type (see Fig.1) in which both initial and final states are considered in the valence quark approximations. The $C_{\pm}$ coefficients of effective Hamiltonian (2) in this approach are regarded as pure phenomenological parameters. They are not calculable in QCD perturbation theory, but we can extract them as inputs directly from experimental data.

In the spectator model the relations between the amplitudes of two- and quasi-two-body nonleptonic decays of a certain type (e.g. $\mathcal{D}\to 2P$, VP or $2V$) depend on the single parameter δ determined according to (5) by the c_-/c_+ ratio. These relations look quite different depending upon the value of δ. At $|\delta| \ll 1$, i.e. in the region close to the QCD prediction $\delta = -0.15$ (c_+ and c_- as in (3)) the total width of $\mathcal{D}^0$ two-body decays is close to the corresponding width of $\mathcal{D}^+$. But if $\delta \to -1$, the suppression of $\mathcal{D}^+$ two-body decays takes place due to the cancellation of Fig.1a and Fig. 1b diagrams. Simultaneously, the $\mathcal{D}^0$ two-body decays are enhanced and in particular $\Gamma(\mathcal{D}^0 \to \bar{K}^0 \pi^0)$ becomes close to $\Gamma(\mathcal{D}' \to K^- \pi^+)$ in accordance with (6). At the same time, as it was argued in Ref.[14], in three- or many-body decays where the number of independent quark diagrams is already large, the situation is more complicated and is not controlled by a single parameter δ. Fixing any particular value of δ one cannot simultaneously suppress all $\mathcal{D}^+$ many-body decay modes and enhance the corresponding $\mathcal{D}^0$ modes.

Taking the abovementioned arguments into account the following main conclusion has been made in Ref.[14]. If two- and quasi-two-body modes dominate in D-meson decays, then the spectator model can naturally explain the large difference between $\tau(\mathcal{D}^+)$ and $\tau(\mathcal{D}^0)$ due to the fact that δ-value may approach -1.

The very observation [1] of quasi-two-body modes $\mathcal{D} \to VP$ saturating some of the $\mathcal{D} \to 3P$ decays supports this conclusion. Moreover, quantitative estimates are possible which will clarify our viewpoint.

To fix the value of δ which determines all relations between two- or quasi-two-body decays we may use the following experimental input for which two independent measurements [1, 16] give nearly the same value:

$$\frac{BR(\mathcal{D}^+ \to \bar{K}^0 \pi^+)}{BR(\mathcal{D}^0 \to K^- \pi^+)} \simeq 0{,}8 \tag{7}$$

The absolute widths of these decays are related[1,5] by

$$\Gamma(\mathcal{D}^+ \to \bar{K}^0 \pi^+) = (1+\delta)^2 \, \Gamma(\mathcal{D}^0 \to K^- \pi^+) \tag{8}$$

Therefore

$$(1+\delta)^2 \simeq 0.8 \left[\tau(\mathcal{D}^0) / \tau(\mathcal{D}^+) \right]$$

For the ratio of mean lifetimes we take the interval

$$\tau(\mathcal{D}^+)/\tau(\mathcal{D}^0) = 3 \div 10 \tag{9a}$$

that along with the corresponding intervals of semileptonic branching ratios

$$\begin{aligned} BR(\mathcal{D}^0 \to e^+ + \cdots) &= (5 \div 2.5)\% \\ BR(\mathcal{D}^+ \to e^+ + \cdots) &= (15 \div 25)\% \end{aligned} \tag{9b}$$

embrace the whole range of experimental data[1, 16]. Hence we obtain two possibilities:

$$\delta = -(0.5 \div 0.7) \tag{10a}$$

or

$$\delta = -(1.5 \div 1.3) \tag{10b}$$

Hereafter the first (second) number quoted in (÷) intervals corresponds to the lower (upper) limit in (9a). Note that in both cases (10a) and (10b) the value of δ does not substantially change with the variation of $\tau(\mathcal{D}^+)/\tau(\mathcal{D}^0)$.

The interval (10a) being far from the QCD value of $\delta = -0.15$ is nevertheless within the range of ±50% variation of $C_\pm$ coefficients around their QCD values (3). In this connection it is worth recalling that the combination of effective Hamiltonian with the valence quark model has been applied earlier in Ref.[15] to various nonleptonic decays of K-mesons and hyperons. A meaningful description of these decays has been obtained. At the same time the coefficients of effective Hamiltonian calculated in leading log approximation and extrapolated into the large distance region have turned out to be uncertain up to $\sim$ 50%.

Returning to the estimates of δ note that the interval (10b) is in better agreement with the relation (4) if we substitute the experimental number (6). At the same time at $\tau(\mathcal{D}^+)/\tau(\mathcal{D}^0)<5$ the values of δ determined from (8) by means of (7) and from (4) by means of (6) already contradict each other.

If further measurements prove the value of $BR(\mathcal{D}^0\to\bar{K}^0\pi^0)$ close to (6) (now this value is based on eight events only[1]), it will mean that the parameter δ determined in the spectator model substantially differs from the QCD prediction. Indeed, (10b) leads to $C_+/C_- = -(0.1\pm0.06)$ that besides being much smaller than (3) also corresponds to different signs of C_+ and C_- .

The new data [1] allows to choose among two possibilities (10a) and (10b) more or less definitely. To do that let us compare the spectator model relation[3]

$$\frac{BR(\mathcal{D}^0\to\bar{K}^{*0}\pi^0)}{BR(\mathcal{D}^0\to K^-\rho^+)} = (0.865)\,\frac{\delta^2}{2} \tag{11}$$

(in parentheses is the relative phase space factor) with the experimental numbers [1]:

$$BR(\mathcal{D}^0\to\bar{K}^{*0}\pi^0) = (1.4 \pm {}^{2.3}_{1.4})\%$$

$$BR(\mathcal{D}^0\to K^-\rho^+) = (7.2 \pm 3)\%$$

The central values corresnond to $|\delta| = 0.7$. Similarly, the substitution of $BR(\mathcal{D}^0 \to \bar{K}^0 \rho^0) = 0.1 \pm {}^{0.6}_{0.1}$ and $BR(\mathcal{D}^0 \to K^{*-}\pi^+) = (3.4 \pm 1.4)\%$ (the quoted average [1]) into the analogous relation

$$\frac{BR(\mathcal{D}^0 \to \bar{K}^0 \rho^+)}{BR(\mathcal{D}^0 \to K^{*-}\pi^+)} = \frac{\delta^2}{2 \cdot (0.865)} \tag{12}$$

leads to $|\delta| = 0.2$ (again for central values).

In Fig.3 the intervals of $|\delta|$ (with the account of experimental errors) are represented as compared with the QCD-prediction taken with ±50% variation. It is seen that the interval $|\delta| = 0.5 \div 0.7$ is in better agreement with other experimental inputs. Of course, large errors make it so far impossible to clarify whether we can establish any universal value of δ for all two-body decays. Note that from a purely phenomenological point of view different values of δ for different decay types (e.g. δ_{2P}, δ_{VP} δ_{2V}) are not excluded in the framework of the spectator model. Nevertheless we assume here that the simplest variant of this model works. So we take universal $\delta = -(0.5 \div 0.7)$ (the sign is in accord with QCD prediction).

We conclude that actually δ is far from -1, which is the ideal value for cancellations in $\mathcal{D}^+$ decay diagrams. Let us show, however, that the cancellation mechanism in fact works in this "intermediate" case also, yielding $\tau(\mathcal{D}^+) > \tau(\mathcal{D}^0)$.

For this reason we shall use the simple relations that naturally arise [14] in the spectator approach between nonleptonic and semileptonic widths of D-mesons. These relations directly follow from the factorization properties of quark diagrams in the SU(3)-limit . The final expressions obtained in Ref.[14] contained in some cases incorrect numerical phase space factors.

The correct relations are the following:

$$(0.5)\Gamma(\mathcal{D}^0\to K^-\rho^+)=(0.55)\Gamma(\mathcal{D}^0\to K^-\pi^+)=\alpha^2\Gamma(\mathcal{D}^0\to K^-e^+\nu) \quad (13a)$$

$$(0.55)\Gamma(\mathcal{D}^0\to K^{*-}\rho^+)=(0.63)\Gamma(\mathcal{D}^0\to K^{*-}\pi^+)=\alpha^2\Gamma(\mathcal{D}^0\to K^{*-}e^+\nu) \quad (13b)$$

$$(0.5)\Gamma(\mathcal{D}^+\to \bar{K}^0\rho^+)=\alpha^2\Gamma(\mathcal{D}^0\to K^-e^+\nu)\times$$
$$\times\left\{1+(1.04)\delta\sqrt{\frac{\Gamma(\mathcal{D}^0\to K^{*-}e^+\nu)}{\Gamma(\mathcal{D}^0\to K^-e^+\nu)}}\right\} \quad (13c)$$

Here we assume that the $\langle\mathcal{D}|K\rangle$ and $\langle\mathcal{D}|K^*\rangle$ formfactors have the same sign and are Q^2 -independent; $\alpha=(2C_+ + C_-)/3$.

Combining (13) with the relations between nonleptonic decay widths that follow from the spectator model itself [3] we can easily express the widths of all $\mathcal{D}\to 2P$, VP, $2V$ decay modes in the units of total semi-leptonic width $\Gamma(\mathcal{D}^0\to e^+ + \cdots)$ taking into account that [16] $Ke\nu$ ($K^*e\nu$) final state makes 55% (39%) of this width. To estimate the parameter α entering (13) we use (13a)

$$\alpha^2 = 0.55\,BR(\mathcal{D}^0\to K^-\pi^+)/BR(\mathcal{D}^0\to K^-e^+\nu) = 0.6\div 1.1$$

at $BR(\mathcal{D}^0\to e^+ + \cdots)$ = (5 ÷ 2.5)%. Along with δ = -(0.5 ÷ 0.7) it corresponds to the following phenomenological values of C_+ and C_- :

C_- = 1.7 ÷ 2.7

C_+ = 0.31 ÷ 0.22

Table 1 represents the resulting nonleptonic widths in the units of $\Gamma(\mathcal{D}^0 \to e^+ + \cdots)$. For completeness the corresponding predictions at QCD values of $C_\pm$ as well as the widths of F-meson are presented.

If we sum over the calculated two- and quasi-two-body widths (the resulting sums denoted as $\Gamma(\mathcal{D} \to 2P, VP, 2V)$ are given in Table 1) and neglect the rest of $\mathcal{D}^+, \mathcal{D}^0$ nonleptonic modes, then the following estimate is immediately obtained:

$$\frac{\tau(\mathcal{D}^+)}{\tau(\mathcal{D}^0)} \simeq \frac{\Gamma(\mathcal{D}^0 \to 2P, VP, 2V) + 2}{\Gamma(\mathcal{D}^+ \to 2P, VP, 2V) + 2} = 2 \div 3 \tag{14}$$
$$(\delta = -(0.5 \div 0.7))$$

This estimate indicates that the cancellation mechanism really works and at least for $\tau(\mathcal{D}^+)/\tau(\mathcal{D}^0) \sim 3$ the spectator model reproduces the experimental situation selfconsistently.

Of course, the contribution of $2P$, VP and $2V$ modes is far from saturating the total widths of D-mesons. Indeed, from (14) we have:

$$BR(\mathcal{D}^0 \to e^+ + \cdots) \sim (20 \div 13)\%$$
$$BR(\mathcal{D}^+ \to e^+ + \cdots) \sim (40 \div 42)\%$$

which is more than the quoted values (9b). To restore the full consistence with experiment the contribution of neglected modes into the $\mathcal{D}^0$ total width must be at the level of $\Gamma(\mathcal{D}^0 \to VP, 2P, 2V)$. Simultaneously, the analogous contribution to the $\mathcal{D}^+$ total width must also be suppressed. Such situation may be well reproduced by the cancellation mechanism due to quasi-two-body modes that we have ignored, e.g. with scalar or axial mesons in final state. To confirm this conjecture a further careful search for resonant structures is needed in three- and four-body final states of D-meson nonleptonic decays.

A few final remarks are to the point.

Having $\mathcal{D}\to VP$ branching ratios at our disposal we can directly test the relations (13) that link the decays of different types in spectator model. Dividing the second equation in (13a) by the second one in (13b) we obtain

$$\frac{BR(\mathcal{D}^0\to K^-\pi^+)}{BR(\mathcal{D}^0\to K^{*-}\pi^+)} \simeq \frac{(1.1)BR(\mathcal{D}^0\to K^-e^+\nu)}{BR(\mathcal{D}^0\to K^{*-}e^+\nu)}$$

independent of any parameter. This last relation is confirmed fairly well by data [1] provided that the ratio $K^*e\nu/Ke\nu$ = 0.39/0.55 [16]. Simultaneously the limit [1] $BR(\mathcal{D}^+\to\bar{K}^0\rho^+) > (15 \div 40)\%\ BR(\mathcal{D}^+\to\bar{K}^0\pi^+\pi^0)$ is consistent with (13c) if we substitute the same ratio in and choose δ and $\tau(\mathcal{D}^+)/\tau(\mathcal{D}^0)$ as before. From the first equation in (13b) unambiguously follows that $K^{*-}\rho^+$ mode of $\mathcal{D}^0$ is expected at the same level as $K^{*-}\pi^+$. Finally, we note that (7 ± 3)% [1] for $BR(\mathcal{D}^0\to K^-\rho^+)$ is somewhat higher to confirm (13a). Maybe, this disagreement hints that the constant formfactor approximation yielding (13) is too crude and the Q^2-dependence is to be accounted.

Note also that the $\mathcal{F}^+$-meson decays may provide very important information. In particular from Table 1 we obtain that $\tau(\mathcal{F}^+)\simeq\tau(\mathcal{D}^0)$ is expected independent of δ-value.

Our final conclusion is that the spectator model of charmed meson nonleptonic decays is viable from the phenomenological point of view. It reproduces the experimental situation in terms of a small number of parameters. However, unless the experimental data are substantially improved the model can't be finally established. In any case, the value of $\tau(\mathcal{D}^+)/\tau(\mathcal{D}^0)$ exceeding

$2 \div 3$ seems too high and unnatural from the point of view of the spectator approach. Note that quite recently the first direct observation [7] of rather long lived $\mathcal{D}^0$ has been reported.

The author would like to thank S.V.Esaybegyan, D.Fakirov and S.Petkov for useful discussions. This work has been performed during our visit to the Institute of Nuclear Research and Nuclear Energy of Bulgarian Academy of Sciences. I am grateful to Prof. Ch.Christov and to the members of theoretical laboratory for the kind hospitality.

Table 1. The widths of two-body nonleptonic decays of D-F-mesons in the units of total semileptonic width

Decay mode	$\Gamma / \Gamma(\mathcal{D}^0 \to e^+ + \dots)$	
	$\delta = -0,5 \div 0,7$	$\delta = -0,I5$
$\mathcal{D}^0 \to K^-\pi^+$	$0,6 \div I,I$	I,2
$\bar{K}^0\pi^0$	$0,075 \div 0,3$	0,0I
$\bar{K}^0\eta$	$0,02 \div 0,08$	0,004
$\bar{K}^0\eta'$	$0,03 \div 0,I$	0,006
$K^-\rho^+$	$0,7 \div I,2$	I,3
$\bar{K}^0\rho^0$	$0,09 \div 0,3$	0,0I
$\bar{K}^0\omega$	$0,09 \div 0,3$	0,0I
$\bar{K}^{*0}\pi^0$	$0,075 \div 0,25$	0,0I
$K^{*-}\pi^+$	$0,4 \div 0,7$	0,8
$\bar{K}^{*0}\eta$	$0,0I \div 0,04$	0,002
$\bar{K}^0\phi$	0	0
$K^{*-}\rho^+$	$0,4 \div 0,8$	0,87
$\bar{K}^{*0}\rho^0$	$0,05 \div 0,2$	0,0I
$\bar{K}^{*0}\omega$	$0,05 \div 0,2$	0,0I
$\Gamma(\mathcal{D}^0 \to 2P, VP, 2V)$	$2,6 \div 5,6$	4,2
$\mathcal{D}^+ \to \bar{K}^0\pi^+$	$0,I5 \div 0,I$	0,87
$\bar{K}^0\rho^+$	$0,2 \div 0,4$	0,99
$\bar{K}^{*0}\pi^+$	$0,I \div 0,02$	0,6I
$\bar{K}^{*0}\rho^+$	$0,I \div 0,07$	0,62
$\Gamma(\mathcal{D}^+ \to 2P, VP, 2V)$	$0,55 \div 0,6$	3,I

Table 1. (continued)

Decay mode	$\Gamma/\Gamma(D^0 \to e^+ + \cdots)$	
	$\delta = -0{,}5 - 0{,}7$	$\delta = -0{,}I5$
$F^+ \to \eta\pi^+$	0,4 ÷ 0,7	0,7
$\pi^+\pi^0$	0	0
$\eta'\pi^+$	0,I5 ÷ 0,3	0,3
$K^+\bar{K}^0$	0,I ÷ 0,5	0,02
$\rho^+\eta$	0,7 ÷ I,I5	I,2
$\rho\pi, \omega\pi^+$	0	0
$\phi\pi^+$	0,35 ÷ 0,6	0,7
$\rho^+\eta'$	0,I ÷ 0,2	0,2
$K^{*+}\bar{K}^0$	0,I ÷ 0,2	0,02
$\bar{K}^{*0}K^+$	0,2 ÷ 0,5	0,03
$\rho^+\phi$	0,4 ÷ 0,8	0,8
$\bar{K}^{*0}K^{*+}$	0,I ÷ 0,4	0,02
$\rho^+\rho^0, \rho^+\omega$	0	0
$\Gamma(F^+ \to 2P, VP, 2V)$	2,6 ÷ 5,3	4,0

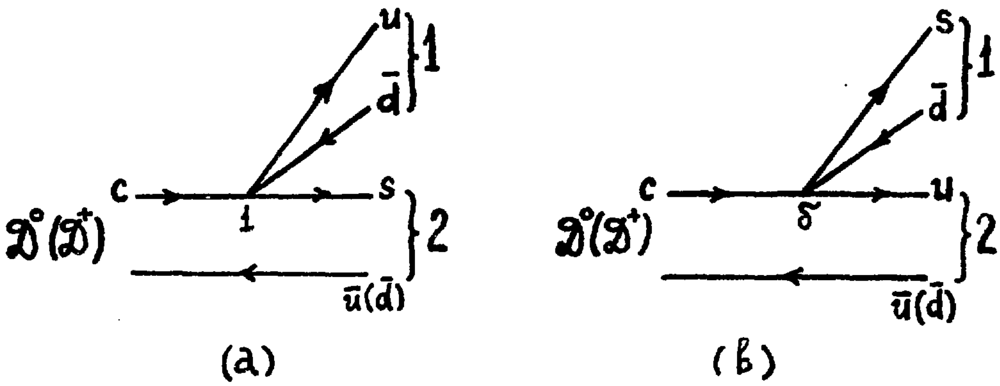

Fig.1. The spectator type quark diagrams corresponding to the two- and quasi-two-body decays $\mathcal{D} \rightarrow 1 + 2$. The ratio of diagrams $(b)/(a)$ is equal to δ

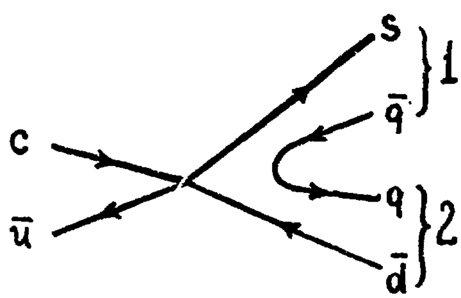

Fig.2. The quark diagram of annihilation type corresponding to $\mathcal{D}^{0}$ two-body decay.

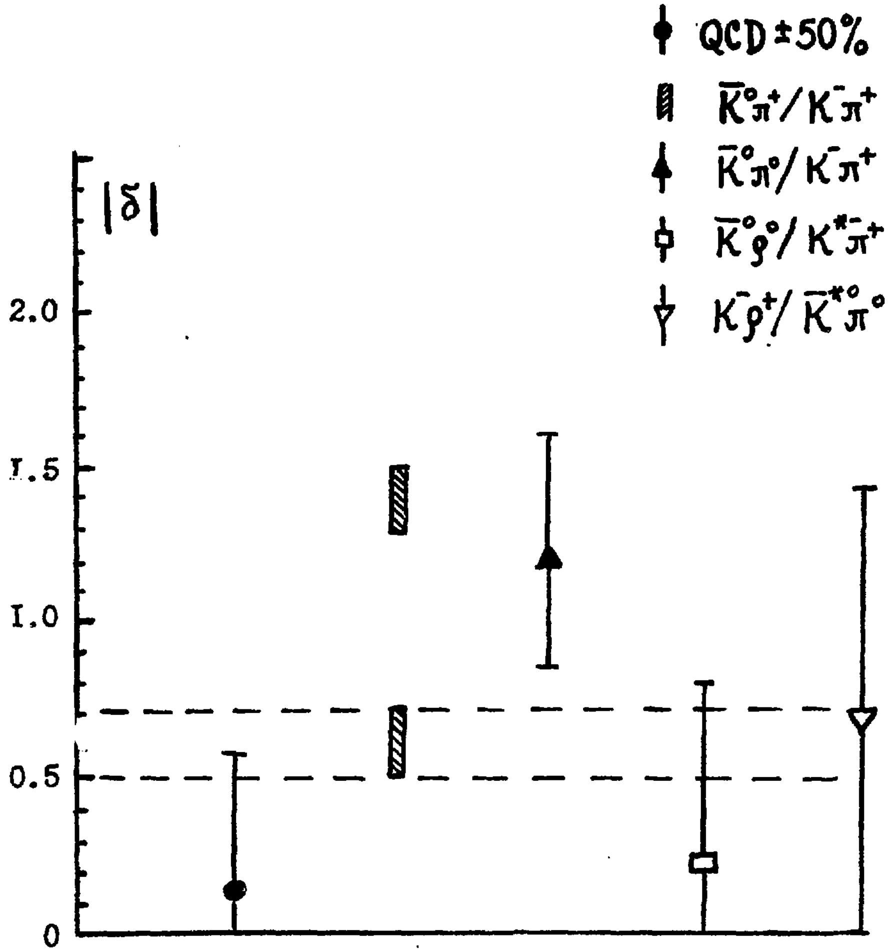

Fig.3. The intervals of δ -value extracted from the experiment in various ways versus QCD prediction.

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$\mathcal{D}$ -МЕЗОНОВ И ЭКСПЕРИМЕНТ

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