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ABSTRACT

The statistical quark model of particle clusters describing succesfully the nucleon-antinucleon final state is applied to calculate the distribution of final states in the weak decays of the hypothetical charmed mesons. Leptonic as well as non-leptonic decays are considered. It is shown that the amount of kaon excess compared to the nucleon-antinucleon fireball is model dependent and not necessarily large.

АННОТАЦИЯ

Статистическая кварковая модель, которая хорошо описывает анигиляцию нуклон-антинуклон, применяется на вычисление распределения конечных состояний в слабых распадах гипотетических мезонов с чармом. Рассматриваются и лептонные и нелептонные распады. Показываем, что избыток каонов по сравнению с файерболом нуклон-антинуклон зависит от модели и не обязательно большой.

KIVONAT

A nukleon-antinukleon annihilációt jól leiró statisztikus kvark modellt alkalmazzuk a hipotetikus "bájos" mezonok gyenge bomlásaiban keletkező végállapotok eloszlásának számitására. Leptonikus és nemleptonos bomlásokat egyaránt vizsgálunk. Megmutatjuk, hogy a kaontöbblet - összevetve a nukleon--antinukleon tüzgolyóval - modellfüggő és nem szükségképpen nagy.

I. INTRODUCTION

A possible explanation of the recently discovered narrow resonances [1] is that, within the framework of the quark model, these particles are bound states of a charmed quark /c/ and its antiquark /$\bar{c}$/. The existence of charmed quarks implies an SU/4/ spectroscopy for meson and baryon states. The crutial test of this idea is to find the non-zero charm members of the meson /and baryon/ multiplets. The charmed mesons /D and F/ we shall consider have large masses /a typical estimate based on SU/4/ mass-formulae is roughly $m_D \cong m_F \cong 2$ GeV/ and decay weakly as charm is conserved in strong and electromagnetic interactions [2]. Due to the large mass a large number of multibody hadronic final states is open for the decay. This makes detailed theoretical predictions concerning exclusive branching ratios, average multiplicities etc. very difficult /if not impossible/. The only possibility is to construct simplified, statistical models with the aim of predicting general features of the hadronic final states.

In the present paper we apply a statistical quark model [3-4] to calculate the branching ratios for the weak decays of charmed mesons. The D and F mesons contain a charmed quark together with an ordinary /non-charmed/ quark. The decay is triggered by the weak process transforming the charmed quark into ordinary quarks. We assume that the branching ratios are governed by the strong final state interaction. In other words, the released energy transforms the hadron state into a "fireball" similar to the one encountered in nucleon-antinucleon annihilation at rest. The energy release is in fact, almost the same in the two cases the only essential difference being in the initial SU/3/ quantum numbers. Since our model describes the nucleon-antinucleon annihilation process /including SU/3/-structure/ reasonably well [4-5] this part of the model seems reliable. More freedom and uncertainty is present in the weak process producing the fireball, particularly in the non-leptonic case. There we try to take several simple illustrative models in order to show to what extent the different possibilities give rise to different distributions. The less model dependent case of the semi-leptonic decays is considered in Chapter III. whereas nonleptonic decays are dealt with in Chapter IV. Chapter II. is a brief summary of the statistical quark model for fireball decay.

II. FIREBALL DECAY

The statistical quark model of the fireball decaying into a cluster of hadrons was described in detail previously [3-4]. Here we only summarize its main features and final results. The /mesonic/ fireball is characterized by the quark-antiquark quantum number $q_1\bar{q}_2$. During the fireball decay process the quark and the antiquark emit /pseudoscalar and vector/ mesons subsequently, statistically and independently from each other. Higher /e.g. tensor/ resonance emission as well as spin and polarization effects are neglected /although, in principle, these effects can be taken into account at a later stage/.

The distribution of the final states is determined by a quantity $Z_{q_1\bar{q}_2}$ /the "sum over final states" satisfying the equation

$$Z_{q_1\bar{q}_2} = D_{q_1q_2} + BD_{q_1q_1'}Z_{q_1'\bar{q}_2} + \\ + BZ_{q_1\bar{q}_2'}D_{q_2'q_2} - B^2D_{q_1q_1'}Z_{q_1'\bar{q}_2'}D_{q_2'q_2} \qquad /1/$$

Here the matrix D is given by

$$D = \begin{pmatrix} \frac{\pi_o+\eta_n}{2} + x\,\frac{\rho_o+\omega}{2} & \pi_+ + x\rho_+ & K_+ + xK_+^* \\ \pi_- + x\rho_- & \frac{\pi_o+\eta_n}{2} + x\frac{\rho_o+\omega}{2} & K_o + xK_o^* \\ K_- + xK_-^* & \bar{K}_o + x\bar{K}_o^* & \eta_s + x\Phi \end{pmatrix} \qquad /2/$$

where

$$\eta_n = 0.72\eta + 0.28\eta'$$
$$\eta_s = 0.28\eta + 0.72\eta' \qquad /3/$$

B is a parameter of dimension mass^{-2}, x gives the ratio of vector meson to pseudoscalar meson coupling constants. These two parameters were determined from nucleon-antinucleon annihilation data [5]: $B = 3.3$ GeV^{-2}, $x = 4$.* For the vector meson nonet ideal mixing was choosen. The pseudoscalar mixing given by Eq./3/ corresponds to the linear mass-formula. The matrix D in Eq./2/ implies exact SU/3/-symmetry and exact Zweig-rule for couplings. /SU/3/-breaking is taken into account only in the masses./

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*SU/6/ would correspond to $x = 3$. The parameter B was denoted in Ref. [5] by 2a

The solution of Eq. /1/ is

$$Z_{q_1\bar{q}_2} = \left[(1-BD)^{-1}D\ (1-BD)^{-1}\right]_{q_1 q_2} = \sum_{n=1}^{\infty} nB^{n-1}(D^n)_{q_1 q_2} \qquad /4/$$

This is determined once we are able to calculate the n'th power of the matrix D. For brevity, let us now consider pseudoscalar mesons only /the inclusion of vector mesons is straightforward in the final formula/. In this case we have

$$(1-D)^{-1} = 1 + D + D^2 + \ldots =$$

$$= \left[\det(1-D)\right]^{-1} \begin{pmatrix} (1-\frac{\pi_o+\eta_n}{2})(1-\eta_s)-K_o\bar{K}_o & \pi_-(1-\eta_s)+K_-K_o & \pi_-K_o+K_-(1-\frac{\pi_o+\eta_n}{2}) \\ \pi_+(1-\eta_s)+K_+\bar{K}_o & (1-\frac{\pi_o+\eta_n}{2})(1-\eta_s)-K_+K_- & \pi_+K_-+(1-\frac{\pi_o+\eta_n}{2})\bar{K}_o \\ \pi_+K_o+K_+(1-\frac{\pi_o+\eta_n}{2}) & \pi_-K_++(1-\frac{\pi_o+\eta_n}{2})K_o & (1-\frac{\pi_o+\eta_n}{2})^2-\pi_+\pi_- \end{pmatrix}$$

/5/

where

$$\det(1-D) = (1-\eta_s)\left[(1-\frac{\pi_o+\eta_n}{2})^2 - \pi_+\pi_-\right] - (1-\frac{\pi_o+\eta_n}{2})(K_+K_- + K_o\bar{K}_o) -$$

$$- (K_+\bar{K}_o\pi_- + K_-K_o\pi_+) \qquad /6/$$

After simple but tedious algebraic manipulations we obtain

$$(1-D)^{-1}_{q_1q_2} = \sum_{\ell_1,\ldots,\ell_6=o}^{\infty} (K_+\bar{K}_o\pi_- + K_-K_o\pi_+)^{\ell_1} (K_+K_- + K_o\bar{K}_o)^{\ell_2}$$

$$\eta_s^{\ell_3}(\pi_+\pi_-)^{\ell_4}(\frac{\pi_o}{2})^{\ell_5}(\frac{\eta_n}{2})^{\ell_6}\ S_{q_1q_2}\ ;$$

$$S_{ud} = \pi_-\frac{(\ell_1+\ell_2)}{(\ell_1+\ell_2+\ell_3)} + K_oK_-\ ,$$

$$S_{us} = \pi_-\bar{K}_o + K_-\frac{(2\ell_1+\ell_2+2\ell_4+1)}{(2\ell_1+\ell_2+2\ell_4+\ell_5+\ell_6+1)}\ ,$$

$$S_{ds} = \pi_-K_+ + \bar{K}_o\frac{(2\ell_1+\ell_2+2\ell_4+1)}{(2\ell_1+\ell_2+2\ell_4+\ell_5+\ell_6+1)}\ ,$$

$$S_{ss} = \frac{(\ell_1+\ell_2)}{(\ell_1+\ell_2+\ell_4)} \cdot \frac{(2\ell_1+\ell_2+2\ell_4)}{(2\ell_1+\ell_2+2\ell_4+\ell_5+\ell_6)} \cdot \frac{(2\ell_1+\ell_2+2\ell_4+1)}{(2\ell_1+\ell_2+2\ell_4+\ell_5+\ell_6+1)} , \qquad /7/$$

$$S_{uu}-K_+K_- = S_{dd}-K_o\bar{K}_o = \frac{(\ell_1+\ell_2)}{(\ell_1+\ell_2+\ell_3)} \cdot \frac{(\ell_1+\ell_4)}{(\ell_1+\ell_2+\ell_4)} \cdot \frac{(2\ell_1+\ell_2+2\ell_4+1)}{(2\ell_1+\ell_2+2\ell_4+\ell_5+\ell_6+1)} .$$

Here an expression $\frac{(0)}{(0)}$ has to be interpreted always as 1. The number of particles n is given by

$$n = 3\ell_1 + 2\ell_2 + \ell_3 + 2\ell_4 + \ell_5 + \ell_6 + \ell_s \qquad /8/$$

where ℓ_s is 0,1 or 2 depending on the number of particles in a particular term of $S_{q_1q_2}$. D^n is given by Eq./7/ if the summation is extended over terms satisfying Eq./8/.

Formula /7/ can be simplified by putting

$$K_+\bar{K}_o\pi_- + K_-K_o\pi_+ = 2K_1K_o\pi_1,\ K_+K_- + K_o\bar{K}_o = 2K\bar{K},\ \pi_+\pi_- = \pi_1^2 \qquad /9/$$

without any loss in information (π_1 = charged pion, K_1 = charged kaon). The inclusion of vector mesons is then given by the substitutions

$$\pi_o \to \pi_o + x\rho_o$$

$$\eta_n \to \eta_n + x\omega$$

$$\eta_s \to \eta_s + x\phi$$

$$\pi_1^2 \to \pi_1^2 + 2x\pi_1\rho_1 + x^2\rho_1^2 \qquad /10/$$

$$K\bar{K} \to K\bar{K} + 2xK\bar{K}^* + x^2K^*\bar{K}^*$$

$$K_1K_o\pi_1 \to K_1K_o\pi_1 + xK_1K_o\rho_1 + 2xK_1K_o^*\pi_1 +$$

$$+ 2x^2K_1K_o^*\rho_1 + x^2K_1^*K_o^*\pi_1 + x^3K_1^*K_o^*\rho_1 .$$

The branching ratio of a given channel is proportional to the invariant phase space /i.e. momentum space integral/ multiplied by some factor. This factor can be red off from Eq. /4/ using Eqs./7-8/. It is standing in front of the term with the given set of pseudoscalar and vector meson states.

III. SEMI-LEPTONIC DECAYS

Up to now we considered only the second half of the process, namely the strong decay of the fireball. The fireball itself is produced by the weak decay of the charmed quark /c/. The basic leptonic process is [2]

$$c \to \ell_+ \nu_\ell \; s \cos\Theta + \ell_+ \nu_\ell d \sin\Theta \qquad /11/$$

ℓ is an electron or muon, Θ is the Cabibbo-angle. In what follows we shall consider only the dominant part proportional to $\cos\Theta$.

The D_o meson is a $/c\bar{u}/$ bound state, D_+ is $/c\bar{d}/$ and F_+ is $/c\bar{s}/$. /We do not distinguish charmed pseudoscalar and vector mesons as spin effects are neglected and the SU/4/ mass formulae predict relatively small mass differences between them./ As a consequence, by the emission of the lepton pair we have the transitions

$$\begin{aligned} D_o &\to \ell_+ \nu_\ell (s\bar{u}) \\ D_+ &\to \ell_+ \nu_\ell (s\bar{d}) \qquad /12/ \\ F_+ &\to \ell_+ \nu_\ell (s\bar{s}) \end{aligned}$$

The fireball $/q_1\bar{q}_2/$ decays according to the previous chapter into a cluster of ordinary hadrons.

The mass of the $/q_1\bar{q}_2/$ system is, of course, smaller than the charmed meson mass due to the four-momentum taken away by the lepton pair. We consider the lepton pair emission and hadron emission on the same footing. That is, also the lepton pair emission is statistical. Of course, it occurs in the emission chain to a much smaller rate due to the small coupling constant [6]. The probability of the lepton pair emission with four-momentum p_1, p_2 is proportional to

$$\sigma(r')\delta^4(r-r'-p_1-p_2)\delta_o(p_1^2-m_1^2)\delta_o(p_2^2-m_2^2) \qquad /13/$$

Here m_1, m_2 are the lepton masses, r and r' is the four-momentum of the system before and after the lepton pair emission, respectively. $\sigma(r')d^4r'$ is the number of the fireball states at the four-momentum value r'. Compared to Ref. [6], where electromagnetic lepton pair emission was considered, the difference is that the propagator does not appear in the formula. This is due to the very large mass of the virtual weak boson coupled to the weak lepton pair. Another difference is that in the charmed meson, due to quantum number conservation, the weak lepton pair has to be emitted always first /no such constraint holds for electromagnetic lepton pairs/. But quantum number conservation is taken into account by our equations, therefore no special care has to be taken about this.

The result is [6] that the lepton pair, too, is emitted according to phase space. Calculating branching ratios this means that besides the hadrons coming from $/q_1\bar{q}_2/$ also the lepton pair in Eq./12/ has to be included in the phase space factor. The factor multiplying the phase space can be calculated from the hadron part alone /Chapter II/ as the weak process introduces only an overall multiplication factor.

Some characteristic results of the numerical calculation are collected in Table I. for $D_o \to e\nu$ + hadrons decay and in Table II. for $F_+ \to e\nu$ + hadrons /the D_+ decay can be obtained in our model by the isospin reflection $I_3 \to -I_3$ of the hadrons/. We have chosen the masses $m_D = m_F = 2$ GeV. For the D_o all the channels contain at least one kaon. The average number of charged pions is about 1.5. In the final state 2 and 3 hadron states dominate but there are substantial single hadron channels, too, /like K_-, K^*_-/ well suited for the experimental search. The F_+ decay is substantially different as most of its channels contain at least one kaon pair. This has the effect that there are much less pions /the charged pion to kaon ratio is about 0.51/. The 2 hadron final states dominate but single ϕ, η and η' are important.

IV. NONLEPTONIC DECAYS

The dominant non-leptonic process among quarks /proportional to $\cos^2\theta$ in amplitude/ is [2]:

$$cd \to su \qquad /14/$$

This basic process can lead to different kinds of nonleptonic weak transitions in charmed mesons. The weight of the different transitions depends on the properties of the charmed quark-antiquark bound system /such as wave functions etc./ therefore it is unknown at present. In order to get some insight into the problem we shall consider two simple mechanisms separately. At the present stage we can neither determine their relative rates, nore exclude other kinds of transitions. But still we can perhaps infer the general trend of the process from these simple models and at the same time get an idea about the possible degree of model dependence.

The first "annihilation" mechanism following from Eq./14/ is possible for D_o and F_+* /see Figure 1/:

$$D_o : (c\bar{u}) \to (s\bar{d})$$

$$F_+ : (c\bar{s}) \to (u\bar{d}) \qquad /15/$$

The other mechanism following from Eq./14/ is based on

$$c \to su\bar{d} \qquad /16/$$

This gives a four-quark final state which could be considered, for instance, as two separate $/q_1\bar{q}_2/$ fireballs. But in order to simplify things we assume that the dominant process is when u and $\bar{d}$ form a pion /Figure 2/:

$$c \to \pi_+ s \qquad /17/$$

This assumption is consistent with the general trend of pion dominance in statistical models. The mechanism in Eq./17/ results in the following transitions:

$$D_o \to \pi_+ (s\bar{u})$$

$$D_+ \to \pi_+ (s\bar{d}) \qquad /18/$$

$$F_+ \to \pi_+ (s\bar{s})$$

Note the similarity with the leptonic transitions in Eq./12/ : the lepton pair is simply replaced by π_+. This "pion emission" process is depicted on Figure 2. The calculation is very similar to the semi-leptonic case, the only difference is that in the phase space factor an extra pion is included /instead of an extra lepton pair/.

Some characteristic results of our numerical calculation are collected in Tables III-IV. /D_o decay/ and Tables V-VI. /F_+ decay/.** The masses are chosen again as $m_D = m_F = 2$ GeV. For D_o decay the two mechanisms do not differ very much, expect for low particle numbers. The average number of pions is 3.5-4. The π/K ratio is also 3.5-4/ as most of the important channels contain a single pion/. Some good channels for the experimental search are $\pi_+\pi_-\bar{K}_o$, $\pi_+\pi_-\pi_+K_-$ etc. The π_+K_- channel has 0.2 %. The situations is

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* For D_+ the leading process of this kind is proportional to $\cos\Theta \sin\Theta$: $(c\bar{d}) \to (u\bar{d})$

** The D_+ decay is similar to D_o. In the Tables γ's not originating from π_o's are given separately.

somewhat different for F_+. Here the two mechanisms are quite different as the fireball in the annihilation case contains no strange quarks whereas in the pion emission case it contains only strange quarks. The average pion numbers are about 5 and about 2.5 in the two cases, respectively. The average kaon numbers are about 0.2 and 2, respectively. Hence the π/K ratio for F_+ is very much model dependent. The dominant channels are also very different. The similarity betwenn the D_o and F_+ is that the average particle number after the resonance decay is in both cases $\sim$ 5.

V. CONCLUDING REMARKS

A simple statistical model of charmed meson decay was briefly described also in Ref. [2]. Compared to it our model is more realistic as we incorporate resonances, SU/3/ symmetry and quark rules properly. As far as the results are concerned we predict much more particles in the final state. For instance, Table IV. of Ref. [2] says 51 % for the $\bar{K}\pi$ state whereas our estimate is below 1 %. This is in some sense discouraging for experiments as few body channels are, of course, much easier to find. Another /related/ general consequence is that the π/K ratio is substantially larger in our model. However, in most cases it is still smaller than in "ordinary" multiparticle production situations, hence the kaon excess is still a characteristic feature of charmed particle decays.

We checked our model also in kaon decay. It is clearly very much beyond the range of the model to take one or two pions as a multiparticle "fireball" suitable for statistical considerations. Surprisingly enough, charged kaon semileptonic and nonleptonic decays are reproduced reasonably well. The neutral kaon decay comes out very badly but this is a subtle quantum mechanical system with important interference effects. /Such effects are presumably much less important in the D_o-$\bar{D}_o$ system./

Our model cannot predict the relative weight of leptonic versus non-leptonic decays. The current algebra arguments of Ref. [2] say that the leptonic decays /especially the multipion ones/ are probably suppressed. Among the two mechanisms we considered for nonleptonic decays perhaps the pion emission is dominant /this is true in charged kaon decays/. If this is the case, the F-mesons are probably more stable than the D-mesons because of the strange-quark fireball in the former case.

D_o, LEPTONIC.

A	$< n >$		B	HADRONS	%
	$<K_->$	0.55		1	8.7
	$<\bar{K}_o>$	0.45		2	37
	$<\pi_->$	0.88		3	37
	$<\pi_+>$	0.42		4	14
	$2<\pi_o> + <\gamma>$	1.37		5	2.5
				more	0.8

C	channel $(e_+\nu_e)+$	%	channel $(e_+\nu_e)+$	%
	$\pi_-\bar{K}_o$	14	ϕK_-	1
	$\pi_o\pi_-\bar{K}_o$	12	$\pi_o\pi_+\pi_-\pi_-\bar{K}_o$	1
	$\pi_+\pi_-K_-$	12	$\pi_-\bar{K}_o$	1
	π_oK_-	7	$\pi_+\pi_-K^*_-$	1
	K_-	6	$\pi_o\pi_-\bar{K}^*_o$	1
	$\pi_+\pi_-\pi_oK_-$	6		
	$\pi_+\pi_-\pi_-\bar{K}_o$	4		
	$\pi_-\bar{K}^*_o$	4		
	ηK_-	3		
	ρ_oK_-	3		
	ωK_-	3		
	$\pi_o\pi_o\pi_-\bar{K}_o$	3		
	K^*_-	3		
	$\pi_oK^*_-$	2		

$$\frac{\Gamma(D_o \to \mu\nu + \text{hadrons})}{\Gamma(D_o \to e\nu + \text{hadrons})} = 0.78$$

Table: I.: Main Characteristics of $D_o \to e\nu$ + hadrons decay.
A: average multiplicities; B: number of hadrons /resonance = hadron/;
C: channels above the 10^{-2} level.

F_+, LEPTONIC

A	<n>		B	hadrons	%
	$\langle \bar{K}_o \rangle = \langle K_o \rangle$	0.42		0	1.4
	$\langle K_+ \rangle = \langle K_- \rangle$	0.43		1	14
	$\langle \pi_+ \rangle = \langle \pi_- \rangle$	0.24		2	57
	$2\langle \pi_o \rangle + \langle \gamma \rangle$	1.83		3	21
				4	3
				more	3.6

C	channel $(e_+ \nu_e)+$	%
	$K_o \bar{K}_o$	14
	$K_+ K_-$	14
	$K_o \bar{K}^*_o$	7
	$K_+ K^*_-$	7
	$K^*_o \bar{K}_o$	7
	$K^*_+ K_-$	7
	ϕ	6
	$\pi_+ K_o K_-$	6
	$\pi_- \bar{K}_o K_+$	6
	η'	5
	η	4
	$\pi_o K_o \bar{K}_o$	3
	$\pi_o K_+ K_-$	3

$$\frac{\Gamma(F_+ \to \mu\nu + \text{hadrons})}{\Gamma(F_+ \to e\nu + \text{hadrons})} = 0.73$$

Table II.: Main characteristics of $F_+ \to e\nu$ + hadrons decay.
A: average multiplicities; B: number of hadrons /resonance = hadron/;
C: channels above the 10^{-2} level.

D_o, ANNIHILATION

A	channel	%	B	channel after resonance decay	%
	$\rho_+ K^*_-$	1.88		$\pi_o\pi_+\pi_-\pi_+K_-$	16
	$\phi\ \bar{K}^*_o$	0.97		$\pi_o\pi_+\pi_-\bar{K}_o$	15
	$\rho_o\bar{K}^*_o$	0.93		$\pi_o\pi_o\pi_+\pi_-\bar{K}_o$	12
	$\omega\ \bar{K}^*_o$	0.92		$\pi_+\pi_-\pi_+K_-$	8.3
	$\pi_+K^*_-$	0.67		$\pi_o\pi_o\pi_+K_-$	7.0
	ρ_+K_-	0.65		$\pi_+\pi_-\pi_+\pi_-\bar{K}_o$	5.9
	$\phi\ \bar{K}_o$	0.53		$\pi_o\pi_o\pi_+\pi_-\pi_+K_-$	4.6
	$\eta\ \bar{K}^*_o$	0.37		$\pi_o\pi_+\pi_-\pi_+\pi_-\bar{K}_o$	4.4
	$\pi_o\bar{K}^*_o$	0.34		$\pi_o\pi_o\pi_o\pi_+K_-$	3.5
	$\rho_o\bar{K}_o$	0.32		$\pi_o\pi_+K_-$	2.9
	$\omega\ \bar{K}_o$	0.32		$\pi_+\pi_-\bar{K}_o$	2.5
	$\eta'\bar{K}^*_o$	0.27		$\pi_o\pi_o\pi_o\pi_+\pi_-\bar{K}_o$	2.4
	π_+K_-	0.20		$\bar{K}_o(\pi_+K_oK_-+\pi_-\bar{K}_oK_+)$	1.1
	$\eta'\bar{K}_o$	0.12			
	$\eta\ \bar{K}_o$	0.12			
	$\pi_o\bar{K}_o$	0.10		$K_+K_-\bar{K}_o$	0.68
				$K_o\bar{K}_o\bar{K}_o$	0.61
				$\pi_+K_+K_-K_-$	0.78
				$\pi_+\pi_-\pi_+\pi_-\pi_+K_-$	0.97

C		$\langle n_\gamma \rangle$	$\langle n_{\pi_o} \rangle$	$\langle n_{\pi_1} \rangle$	$\langle n_{K_1} \rangle$	$\langle n_{K_o+\bar{K}_o} \rangle$
		0.084	1.24	2.28	0.54	0.54
Prong number	%					
0	4	0.37	2.11	0	0	1.53
2	53	0.11	1.56	1.62	0.38	0.71
4	42	0.023	0.78	3.22	0.78	0.26
6	1	0.021	0.28	5.04	0.96	0.043
8	10^{-3}	0.006	0.041	7.00	1.00	0.003

Table III. Some characteristic features of non-leptonic D_o decay in the annihilation mechanism.
A: quasi-two body channels; B: all the channels above 10^{-2} and charged channels in the range 10^{-2} - 10^{-3}; C: average multiplicities.

D_o, PION EMISSION

A channel	%	B channel after resonance decay	%
		$\pi_o\pi_+\pi_-\pi_+K_-$	20
$\pi_+K^*_-$	0.90	$\pi_o\pi_+\pi_-\bar{K}_o$	14
π_+K_-	0.27	$\pi_+\pi_-\pi_+K_-$	13
		$\pi_+\pi_-\pi_+\pi_-\bar{K}_o$	11
		$\pi_o\pi_o\pi_+\pi_-\bar{K}_o$	8.7
		$\pi_o\pi_+\pi_-\pi_+\pi_-\bar{K}_o$	6.5
		$\pi_o\pi_o\pi_+\pi_-\pi_+K_-$	4.6
		$\pi_+\pi_-\bar{K}_o$	3.7
		$\pi_o\pi_o\pi_+K_-$	2.8
		$\pi_+\pi_-\pi_+\pi_-\pi_+K_-$	2.1
		$\pi_o\pi_+K_-$	1.9
		$\pi_o\pi_o\pi_o\pi_+\pi_-\bar{K}_o$	1.8
		$\pi_o\pi_o\pi_o\pi_+K_-$	1.5
		$\pi_+K_+K_-K_-$	0.78
		$\pi_+K_-K_o\bar{K}_o$	0.62
		$\pi_+\pi_-\pi_+\pi_-\pi_+\pi_-\bar{K}_o$	0.12

C		$\langle n_\gamma \rangle$	$\langle n_{\pi o} \rangle$	$\langle n_{\pi 1} \rangle$	$\langle n_{K1} \rangle$	$\langle n_{K_o+\bar{K}_o} \rangle$
		0.062	0.94	2.74	0.53	0.50
Prong number	%					
2	39	0.13	1.38	1.77	0.23	0.81
4	58	0.020	0.68	3.28	0.72	0.31
6	3	0.015	0.23	5.05	0.95	0.047
8	2.10^{-3}	0.005	0.035	7.00	1.00	0.003

Table IV: Some characteristic features of non-leptonic D_o decay in the pion emission mechanism. A: quasi-two body channels; B: all the channels above 10^{-2} and charged channels in the range 10^{-2}-10^{-3}; C: average multiplicities.

F_+, ANNIHILATION

A channel	%	B channel after resonance decay	%
$\rho_o\rho_+$	0.63	$\pi_o\pi_o\pi_+\pi_-\pi_+$	24
$\omega\ \rho_+$	0.62	$\pi_o\pi_+\pi_-\pi_+\pi_-\pi_+$	13
$\bar{K}^*_o K^*_+$	0.44	$\pi_o\pi_o\pi_o\pi_+\pi_-\pi_+$	12
$\pi_o\rho_+$	0.21	$\pi_o\pi_+\pi_-\pi_+$	11
$\pi_+\rho_o$	0.21	$\pi_+\pi_-\pi_+\pi_-\pi_+$	6.4
$\pi_+\omega$	0.21	$\pi_o\pi_o\pi_+\pi_-\pi_+\pi_-\pi_+$	5.9
$\bar{K}_o K^*_+$	0.17	$\pi_o\pi_o\pi_o\pi_o\pi_+\pi_-\pi_+$	2.8
$\bar{K}^*_o K_+$	0.17	$\pi_o\pi_o\pi_o\pi_+$	2.2
$\eta\ \rho_+$	0.13	$\pi_+(\pi_-K_+\bar{K}_o+\pi_+K_-K_o)$	2.1
$\pi_o\pi_+$	0.06	$\pi_o\pi_o\pi_o\pi_o\pi_+$	1.9
$\bar{K}_o K_+$	0.05	$\gamma\gamma\pi_o\pi_+\pi_-\pi_+$	1.3
$\pi_+\eta$	0.04	$\pi_o\pi_+K_+K_-$	1.1
$\eta'\rho_+$	0.03	$\pi_o\pi_+K_o\bar{K}_o$	1.1
$\pi_+\eta'$	0.01	$\pi_o\pi_+(\pi_-K_+\bar{K}_o+\pi_+K_-K_o)$	1.1
		$\pi_+\pi_-\pi_+$	0.98
		$\pi_+K_+K_-$	0.41
		$\pi_+K_o\bar{K}_o$	0.41
		$\pi_+\pi_-\pi_+K_+K_-$	0.31
		$\pi_+\pi_-\pi_+K_o\bar{K}_o$	0.30
		$\pi_+\pi_-\pi_+\pi_-\pi_+\pi_-\pi_+$	0.42

C		$\langle n_\gamma \rangle$	$\langle n_{\pi_o} \rangle$	$\langle n_{\pi_1} \rangle$	$\langle n_{K_1} \rangle$	$\langle n_{K_o+\bar{K}_o} \rangle$
		0.10	1.76	3.26	0.088	0.087
Prong number	%					
1	11	0.32	2.75	0.90	0.10	0.42
3	61	0.10	1.91	2.89	0.11	0.064
5	27	0.024	1.03	4.97	0.026	10^{-3}
7	1	0.024	0.46	7.00	2.10^{-4}	5.10^{-8}

Table V.: Some characteristic features of non-leptonic F_+ decay in the annihilation mechanism. A: quasi-two body channels: B: all the channels above 10^{-2} and charged channels in the range 10^{-2}-10^{-3}; C: average multiplicities.

F_+, PION EMISSION

A	Channel	%	B	Channel after resonance decay	%
				$\pi_+(\pi_-K_+\bar{K}_o + \pi_+K_-K_o)$	37
				$\pi_o\pi_+(\pi_-K_+\bar{K}_o + \pi_+K_-K_o)$	9.9
				$\pi_o\pi_+K_+K_-$	9.5
	$\pi_+\phi$	3.16		$\pi_o\pi_+K_o\bar{K}_o$	9.1
	$\pi_+\eta'$	0.59		$\pi_+K_+K_-$	8.4
	$\pi_+\eta$	0.28		$\pi_+K_o\bar{K}_o$	7.9
				$\pi_+\pi_-\pi_+K_+K_-$	4.9
				$\pi_+\pi_-\pi_+K_o\bar{K}_o$	4.7
				$\pi_o\pi_o\pi_+K_+K_-$	1.3
				$\pi_o\pi_o\pi_+K_o\bar{K}_o$	1.2
				$\pi_+\pi_-\pi_+(\pi_-K_+\bar{K}_o + \pi_+K_-K_o)$	0.29

C		$\langle n_\gamma \rangle$	$\langle n_{\pi_o} \rangle$	$\langle n_{\pi_1} \rangle$	$\langle n_{K_1} \rangle$	$\langle n_{K_o+\bar{K}_o} \rangle$
		0.049	0.42	1.74	0.99	0.96
prong number	%					
1	20	0.11	0.73	1.00	0	1.92
3	74	0.034	0.36	1.82	1.18	0.78
5	6	0.039	0.17	3.14	1.86	0.049
7	10^{-2}	0.33	1.54	6.87	0.13	$2\cdot10^{-5}$

Table VI Some characteristic features of non-leptonic F_+ decay in the pion emission mechanism. A: quasi-two body channels; B: all the channels above 10^{-2} and charged channels in the range 10^{-2}-10^{-3}; C: average multiplicities.

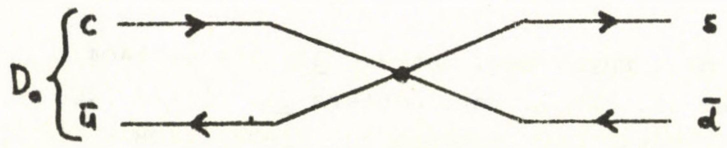

Figure 1. The "annihilation" mechanism for D_0 nonleptonic decay.

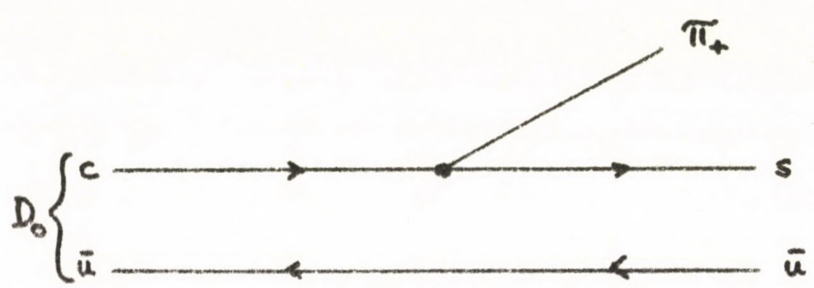

Figure 2. "Pion emission" mechanism for D_0 nonleptonic decay.

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