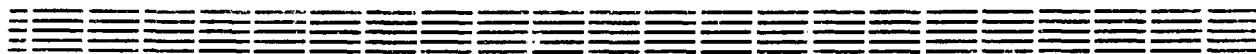


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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
YEREVAN PHYSICS INSTITUTE



G.L.BALAYAN, A.Yu.KHODJAMIRYAN

WEAK DECAYS OF HEAVY MESONS
AND LIGHT MESON MIXING

Նախնատիպ EՓՄ-1033(83)-87

Գ.Լ. ԲԱԼԱՅԱՆ, Ա.ՅՈԼ. ԽՈՋԱՄԻՐՅԱՆ

ԾԱՆՐ ՄԵԶՈՆՆԵՐԻ ԹՈՒՅԼ ՏՐՈՂՈՒՄԸ ԵՎ
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Առաջարկված է թեթև իզոտակալյար մեզոնների քվարկ-հակաքվարկային կազմի որոշման եղանակ՝ հիմնված ծանր Ջ, Յ -մեզոնների թույլ տրոհման որոշակի եղանակների ժամանակ ծնված այդ հաղորդների չափման վրա: Մասնավորապես, այս եղանակով կարելի է անկախորեն որոշել տարօրինակ քվարկների պարունակությունը η^1 -մեզոնում:

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G.L. BALAYAN, A.Yu. KHODJAMIRIAN

WEAK DECAYS OF HEAVY MESONS AND LIGHT
MESON MIXING

A method is suggested to determine the quark-antiquark content of light isoscalar mesons by measurement of the yield of these mesons in definite modes of heavy D, B -meson weak decays. By this method, in particular, the strange quark content in η' may be independently determined.

Yerevan Physics Institute

Yerevan 1987

Препринт ЕФИ-1033(83)-87

Г.Л. БАЛАЯН, А.Ю. ХОДЖАМИРЯН

СЛАБЫЕ РАСПАДЫ ТЯЖЕЛЫХ МЕЗОНОВ
И СМЕШИВАНИЕ ЛЕГКИХ МЕЗОНОВ

Предложен способ определения кварк-антикваркового состава легких изоскалярных мезонов, основанный на измерении выхода этих адронов в определенных модах слабых распадов тяжелых D , B - мезонов. В частности, этим способом можно независимо определить содержание странных кварков в η' - мезоне.

Ереванский физический институт

Ереван 1987

The observation of new light isoscalar mesons η (1440), f_2 (1670),... and the efforts to establish their gluonic nature have raised related problem of the quark-antiquark component of these hadrons as well as the problem of gluon admixture inside "old" isoscalar mesons η (540), η' (958), f_2 (1270),...

Parametrizing the quark content of a given isoscalar meson in the form [1] $\frac{X}{\sqrt{2}} |u\bar{u} + d\bar{d}\rangle + Y |s\bar{s}\rangle$, we may determine the X, Y weights from experimental data. The processes which have been used [1-4] up to now in such phenomenological analysis are η/ψ decays into two mesons, radiative decays, binary reactions of charge exchange type. While for η it is established that $X_\eta^2 + Y_\eta^2 = 1$ the situation for η' is still controversial [5]. Various ways of experimental data treatment lead to different statements about deviation of $X_{\eta'}^2 + Y_{\eta'}^2$ from unity i.e. about additional (gluonic?) component inside η' .

We would like to suggest a new way of determining the quark-antiquark content of light isoscalar mesons. The method consists in detection of these mesons in final states of heavy

\mathcal{D} , \mathcal{B} - meson weak decays. To clarify the idea let us consider the simplest case of \mathcal{D}_s - meson semileptonic decay (Fig. 1a). As a result of $c \rightarrow s e^+ \nu$ decay a pure $s\bar{s}$ system is created in final state. Therefore, registering $\mathcal{D}_s \rightarrow \eta e \nu$, $\mathcal{D}_s \rightarrow \eta' e \nu$ decays we may determine the relative content of strange quarks in η' and η :

$$\text{BR}(\mathcal{D}_s^+ \rightarrow \eta' e^+ \nu) / \text{BR}(\mathcal{D}_s^+ \rightarrow \eta e^+ \nu) = 0,27 \frac{Y_{\eta'}^2}{Y_{\eta}^2} = \begin{cases} 0,20 & \text{a) (I)} \\ 0,48 & \text{b) } \end{cases}$$

The phase space volume ratio is determined here taking into account the $\sim (m_{\mathcal{D}_s}^2 - (P_e + P_\nu)^2)^{-1}$ dependence of semileptonic formfactor on the lepton pair invariant mass. The recent measurements of $\mathcal{D}^0 \rightarrow \bar{K} e^+ \nu$ decay [6] confirm this dependence. The a) value in r.h.s. of Eq.(1) corresponds to the choice $|Y_{\eta}| = 0.83$, $|Y_{\eta'}| = 0.72$ from data on J/Ψ decays into pseudoscalars and vectors [3] while b) corresponds to simple η - η' -mixing without gluon admixture with $\theta = -19^\circ$, i.e. $|Y_{\eta}| = 0.6$, $|Y_{\eta'}| = 0.8$ [5].. Measurements of l.h.s. of Eq.(1) will allow to choose between these two alternatives.

The expected $\mathcal{D}_s^+ \rightarrow \eta e^+ \nu$ width is easily estimated in SU(3)-flavor approximation, normalizing it on the $\mathcal{D}^0 \rightarrow \bar{K} e^+ \nu$ width:

$$\begin{aligned} \text{BR}(\mathcal{D}_s^+ \rightarrow \eta e^+ \nu) &= 1,32 Y_{\eta}^2 \text{BR}(\mathcal{D}^0 \rightarrow \bar{K} e^+ \nu) [\tau_{\mathcal{D}_s} / \tau_{\mathcal{D}^0}] = \\ &= 1,32 Y_{\eta}^2 (4 \pm 1)\% [(4,3 \pm 0,5) \cdot 10^{-13} \text{sec} / (2,8 \pm 0,7) 10^{-13} \text{sec}] \approx \\ &\approx 3,5\% Y_{\eta}^2 = \begin{cases} 2,4\% & \text{a) } \\ 1,3\% & \text{b) } \end{cases} \end{aligned}$$

Unfortunately there is not enough phase space volume for $\eta(1440)$ and other resonances in this mass range (suppression by two orders as compared with $\mathcal{D}_s^+ \rightarrow \eta e^+ \nu$). At the same time it will be very interesting to search for this gluonium candidate in the two-body nonleptonic decay $\mathcal{D}_s^+ \rightarrow \Pi^+ \eta(1440) \rightarrow \bar{K} \bar{K} \Pi$. (diagrams in

Fig. 1b,c). The first (second) one of these diagrams is sensitive to $Y_{\eta(1440)}$ ($X_{\eta(1440)}$) value. Recall, that according to nonleptonic decay models the second diagram is suppressed by helicity. Besides that the dynamics of these decays may be more complicated than in case of semileptonic decays (final state interactions and/or soft gluon exchanges in Fig. 1; b, c diagrams). Nevertheless, the mere observation of $\eta(1440)$ in this decay is a model-independent indicator of a quark-antiquark component inside this meson. Let us note also the following relation:

$$BR(\mathcal{D}^0 \rightarrow \bar{K}^0 \eta') / BR(\mathcal{D}^0 \rightarrow \bar{K}^0 \eta) = 0,73 X_{\eta'}^2 / X_{\eta}^2 = \begin{cases} 0,24 & \text{a)} \\ 0,32 & \text{b)} \end{cases}$$

which is valid independent of the relative contribution of Fig. 1 b,c diagrams. From this relation the nonstrange quark share in η' may be independently extracted.

Owing to larger phase space more interesting perspectives are available in B - meson decays. Thus, many-body semileptonic decays $B^- \rightarrow e^- \bar{\nu} \mathcal{D}^0 + \dots$, $\bar{B}^0 \rightarrow e^- \bar{\nu} \mathcal{D}^+ + \dots$, $B_s^- \rightarrow e^- \bar{\nu} \mathcal{D}_s^0 + \dots$ in principle, serve as sources of respectively $u\bar{u}$, $d\bar{d}$, $s\bar{s}$ states (Fig. 2a diagram). It is still difficult to predict the level of these decays. First measurements of B - meson semileptonic branching ratios [8] as well as theoretical arguments [9] favour the saturation of semileptonic width by $B \rightarrow \mathcal{D}e\nu$, $\mathcal{D}^*e\nu$ modes. At the same time the nonresonance $\mathcal{D} \rightarrow \kappa\pi e\nu$ decay [6] is not negligible leaving some hope for the existence of analogous $B \rightarrow \mathcal{D}Xe\nu$ decays where X is a neutral light meson.

Two-body decays of $\bar{B}^0 \rightarrow \mathcal{D}^{(*)} \eta$ type proceeding from diagrams of Fig. 2b,c are sensitive to $(u\bar{u} + d\bar{d})$ component of η - resonances

(the Fig.2c diagram is also expected to be suppressed). There is enough phase space volume for $\eta(1440) \rightarrow \kappa \bar{\kappa} \pi$ and other η -resonances in this mass range:

$$BR(\bar{B}^0 \rightarrow \mathcal{D}^{(*)} \eta(1440)) / BR(\bar{B}^0 \rightarrow \mathcal{D}^{(*)} \eta) = 0,9(0,7) X_{\eta(1440)}^2 / X_{\eta}^2 \quad (2)$$

At last, strange quarks inside light isoscalar mesons will lead to decays like $\bar{B}_s^0 \rightarrow J/\psi \eta(1440)$ type (Fig.2d):

$$BR(\bar{B}_s^0 \rightarrow J/\psi \eta(1440)) / BR(\bar{B}_s^0 \rightarrow J/\psi \eta) = 0,49 Y_{\eta(1440)}^2 / Y_{\eta}^2 \quad (3)$$

The available information on B -meson exclusive decays [7,8] allows to expect these modes at the level of 0.1 - 1.0%. At the same time it is difficult to say something about the chances for observation of light isoscalars with $J^{PC} = 0^{++}(f_0(975), f_0(1300), f_0(1590) \dots), 1^{++}(f_1(1285), f_1(1420), f_1(1530), \dots), 2^{++}(f_2(1270), f_2(1525), f_2(1720), \dots)$. The relations connecting $X(Y)$ of two f_{η} -mesons are the same as (2) ((3)) if we replace η by f and substitute instead of the quoted phase space factor the corresponding ones. The experimental problem we would like to suggest just now, is the search for f_0 and f_2 resonances in the $\pi^+ \pi^-$ -system in $\bar{B}^0 \rightarrow \mathcal{D}^0 \pi^+ \pi^-$ decay.

A large statistics needed for a detailed search for isoscalar mesons in \mathcal{D}, B -decays may be obtained in \mathcal{D}, B photoproduction experiments at high energies as well as in e^+e^- , $p\bar{p}$ collisions with high luminosity.

In conclusion we note, that the quantitative estimates presented above which take into account only phase space ratios may be incorrect in fact, since these estimates don't reflect the whole dynamics of $q\bar{q}$ -pair hadronization into me-

sons with definite mass (by the way, the same level of accuracy have the relations determining the χ, η -coefficients from other processes [1-5]).

Nevertheless, the main qualitative statement remains valid. The observation of isoscalar meson in definite modes of \mathcal{D}, B weak decays is an indicator of a $q\bar{q}$ -component inside this meson, as in the case with $J/\psi \rightarrow \gamma h$ decays the observation of a given meson h is an indicator of gluon piece inside h .

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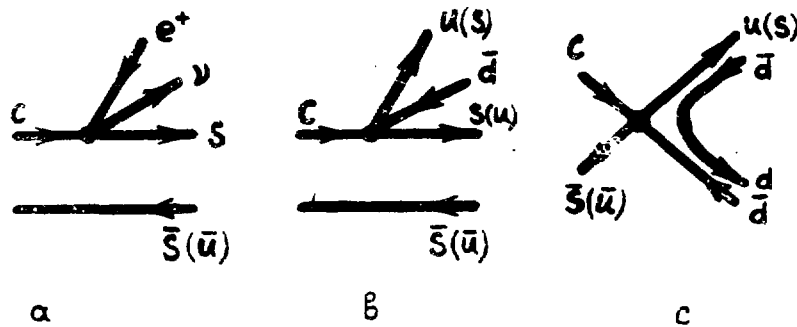


Рис. I

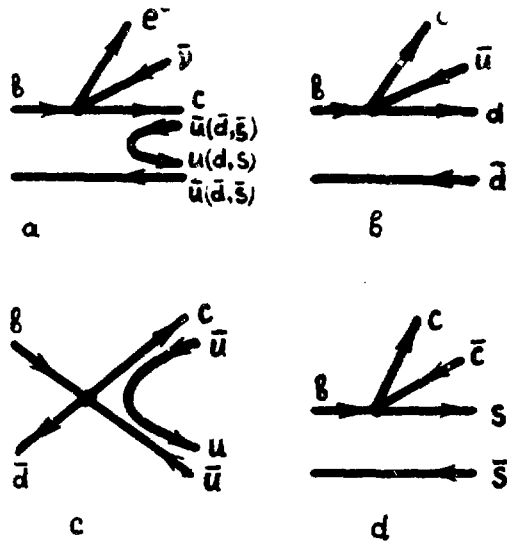


FIG. 2

Figure Captions

Fig. 1 a) The quark diagram of \mathcal{D}_s^+ (\mathcal{D}^0) -meson semileptonic decay; b), c) are quark diagrams corresponding to \mathcal{D}_s^+ (\mathcal{D}^0) -meson nonleptonic decays producing an isoscalar meson.

Fig. 2 a), b), c), d) are quark diagrams corresponding to B - meson semileptonic (nonleptonic) decays producing an isoscalar meson.

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Г.Л.БАЛАЯН, А.Ю.ХОДЖАМИРЯН

СЛАБЫЕ РАСПАДЫ ТЯЖЕЛЫХ МЕЗОНОВ И СМЕШИВАНИЕ ЛЕГКИХ МЕЗОНОВ

(на английском языке, перевод авторов)

Редактор Л.П.Мукаян

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The address for requests:
Information Department
Yerevan Physics Institute
Markaryan St., 2
Yerevan, 375036
Armenia, U SSR

индекс 3624



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