Mass ratios for the *SU*(4) terms of the 20-multiplet and search for *B* mesons

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The mass ratios for the $U(4)$ terms of the 20-multiplet were determined with an accuracy to isotropic splitting. The possibility of including the Y meson in the 20-multiplet composition, which is consistent with the existing experimental data, is considered. The mixing angles in the $(20 + 1)$ multiplet and the masses of the terms of the 20-multiplet of the I^{--} mesons are determined.

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The current experimental data[1] do not allow us to assume the existence of a $(b\bar{q})$-type B meson, where the b quark has a new quantum number-"charm." There is, however, some experimental evidence that mesons with a mass of ~ 5.2 GeV exist.[1]

We have calculated the mass ratios for $U(4)$ 20-mulitplet and analyzed the possibility of incuding a Y mson in the 20-multiplet. Such interpretation of a Y meson, which makes it possible to account for the difficulties arising in the search for B mesons, is consistent with the existing data.

It is noteworthy that, in addition to the difficulties arising in the search for B mesons, the $(t\bar{t})$ states [t is the SU(2)$_{\text{weak}}$ partner of a b quark] are missing up to an energy of ~ 36 GeV. Several models, which are different from the standard model, and the methods for their experimental verification, which can account for the absence of a t quark, have been investigated.[2,3]

We shall analyze the case in which the isospin of one of the Y, Y', and Y'' mesons is equal to unity. As is known, the isospins of all Y mesons in a standard model are equal to zero (the isospins of Y mesons have not yet been determined experimentally[4]). $Y(9,4)$, $Y'(10,0)$, and $Y''(10,3)$ can be included in our case in the terms of the reducible U(4) [U(4)~SU(4)×U(1), where U(1) is the baryon-charge group] multiplet which is a mixture of a singlet and a 20-multiplet.

The ratio of the widths of the decay into e^+e^- terms of the 20-multiplet with $I = 1$ and $I = 0$, which was determined in Ref. 5, is

$$\Gamma_{ee}(I = 1) : \Gamma_{ee}(I = 0) \sim 3 : 1. \tag{1}$$

The relation (1) is valid if the empirical Yennie rule for the 20-multiplet terms can be used [otherwise, the factor, which depends on the meson masses, must be taken into account in Eq. (1)]. The ratio of the widths Γ_{ee} for the singlet C and for the term of the 20-multiplet with $I = 1$, which can be determined in a similar approximation, is

$$\Gamma_{ee}(I = 1) : \Gamma_{ee}(C) \sim 1.5 : 1 . \tag{2}$$

The following ratios have been determined experimentally

$$\Gamma_{ee}(Y') : \Gamma_{ee}(Y) \sim 0.44 \pm 0.06,$$ (3)

$$\Gamma_{ee}(Y'') : \Gamma_{ee}(Y) \sim 0.35 \pm 0.04.$$

We shall show that (3) can be reconciled with (1) and (2) to within $\sim 10\%$ [to improve the accuracy, we must take into account the factor in (1) and (2), which depends on the meson masses, if it can be assumed that (3) henceforth remains the same].

To do this, the neutral term of the 20-multiplet with $I = 1$ must be identified with the $Y(9,4)$ meson and $Y'(10,0)$ and $Y''(10,3)$ must be identified with the H' and C' states, where

$$H' = \cos \phi \, H + \sin \phi \, C,$$ (4)

$$C' = - \sin \phi H + \cos \phi C.$$

H is a neutral of the 20-multiplet with $I = 0$ and C is a singlet.

Two cases are possible here:

$$H' = Y'(10,0), \quad C' = Y''(10,3),$$ (5)

$$\text{tg} \, \phi \sim 0.3, \qquad \phi \approx 17°.$$

$$H' = Y''(10,3), \quad C' = Y'(10,0),$$ (6)

$$\text{tg} \, \phi \sim 0.04, \qquad \phi \sim 2°$$

Conservation of isospin in strong decays gives rise to the fact that, for example, two π mesons in the $Y' \to Y\pi\pi$ reaction must be in the state with $I = 1$, whereas the isospin of a $\pi\pi$ system in the standard $SU(5)_{\text{flavor}}$ scheme must be equal to zero.

The mixing angle can be determined by using the mass ratios which will be determined below.

In relation to the SU(3) subgroup, the 20-multiplet is comprised of an octet of uncharmed mesons with ordinary distribution of quantum numbers, of a sextet and an antisextet of charmed mesons.

The quantum numbers of the sextet are given in Table I. It is convenient to write

	S_0	Δ_0	Δ_1	T_0	T_1	T_2
S	-1	0	0	1	1	1
I	0	1/2	1/2	1	1	1
Q	0	0	1	0	1	2

the 20-multiplet of mesons as a 6×6 matrix

$$
M_{20} = \begin{pmatrix}
\frac{1}{2}\Pi_0 + \frac{1}{\sqrt{12}}H & \frac{1}{\sqrt{2}}\Pi_+ & \frac{1}{\sqrt{2}}G_+ & T_2 & \frac{1}{\sqrt{2}}T_1 & \frac{1}{\sqrt{2}}\Delta_1 \\[8pt]
\frac{1}{\sqrt{2}}\Pi_- & -\frac{1}{2}\Pi_0 + \frac{1}{\sqrt{12}}H & \frac{1}{\sqrt{2}}G_0 & \frac{1}{\sqrt{2}}T_1 & T_0 & \frac{1}{\sqrt{2}}\Delta_0 \\[8pt]
\frac{1}{\sqrt{2}}G_- & \frac{1}{\sqrt{2}}\overline{C}_0 & \frac{2}{\sqrt{12}}H & \frac{1}{\sqrt{2}}\Delta_1 & \frac{1}{\sqrt{2}}\Delta_0 & S_0 \\[8pt]
\overline{T}_2 & \frac{1}{\sqrt{2}}\overline{T}_1 & \frac{1}{\sqrt{2}}\overline{\Delta}_1 & \frac{1}{2}\Pi_0 + \frac{1}{\sqrt{12}}H & \frac{1}{\sqrt{2}}\Pi_- & \frac{1}{\sqrt{2}}G_- \\[8pt]
\frac{1}{\sqrt{2}}\overline{T}_1 & \overline{T}_0 & \frac{1}{\sqrt{2}}\overline{\Delta}_? & \frac{1}{\sqrt{2}}\Pi_+ & -\frac{1}{\sqrt{2}}\Pi_0 + \frac{1}{\sqrt{12}}H & \frac{1}{\sqrt{2}}\overline{G}_0 \\[8pt]
\frac{1}{\sqrt{2}}\overline{\Delta}_1 & \frac{1}{\sqrt{2}}\overline{\Delta}_0 & S_0 & \frac{1}{\sqrt{2}}G_+ & \frac{1}{\sqrt{2}}G_0 & -\frac{2}{\sqrt{12}}H
\end{pmatrix}
$$

where $\Pi_0 = Y(9,4)$.

It is easy to show that the simplest way to split the M_{20} masses to within an accuracy of the mass difference within the isomultiplets is to select a mass operator in the form

$$\hat{M} = aI + b\,k, \tag{7}$$

where I is a 6×6 unit matrix and $\kappa = \text{diag}\,(1,1,-2,1,1,-2)$. The following mass ratios (linear or quadratic) have been obtained for the M_{20} terms in this case:

$$
M_\Pi \equiv M_{\Pi_+} = M_{\Pi_-} = M_{\Pi_0} = M_{T_0} = M_{T_1} = M_{T_2},
$$
$$
M_G \equiv M_{G_+} = M_{G_0} = M_{\Delta_0} = M_{\Delta_1}, \tag{8}
$$
$$
4M_G = 3M_H + M_\Pi \qquad 3M_H = 2M_{S_0} + M_\Pi.
$$

If $\phi \neq 0$, then the last two relations in (8) must be changed with due regard for Eq. (4).

If M_H is dropped in Eq. (8), we obtain the relation (8), which is independent of the mixing angle

$$2M_G = M_{S_0} + M_\Pi. \tag{9}$$

As pointed out in Ref. 5, the absolute mass splitting in M_{20} does not exceed 1 GeV. More precisely, if we use the linear relations (8), we obtain for (5)

$$M_G \sim 9.0 \text{ GeV}, \qquad M_{S_o} \sim 8.6 \text{ GeV}, \tag{10}$$

and for (6)

$$M_G \sim 9.2 \text{ GeV}, \qquad M_{S_o} \sim 9.1 \text{ GeV}. \tag{11}$$

The mass values in (10) ad (11) were obtained on condition that $\Pi_0 = Y(9.4)$. The mass ratios (8), however, can also be used in multiquark models, for example, for the $(qq\bar{q}\bar{q})$-type meson 20-multiplet.

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