IC/92/408

INTERNATIONAL CENTRE FOR
THEORETICAL PHYSICS

# DECAY OF THE BOTTOM MESONS

Duong Van Phi

and

Duong Anh Duc

INTERNATIONAL ATOMIC ENERGY AGENCY

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

MIRAMARE-TRIESTE

IC/92/408

International Atomic Energy Agency
and
United Nations Educational Scientific and Cultural Organization
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

# DECAY OF THE BOTTOM MESONS

Duong Van Phi *
International Centre for Theoretical Physics, Trieste, Italy

and

Duong Anh Duc
Department of Informatics, Hochiminh City University,
Hochiminh City, Vietnam.

MIRAMARE – TRIESTE
December 1992

* On leave of absence from: Department of Theoretical Physics, Hochiminh City University, P.O. Box 657 Central Post Office, Hochiminh City, Vietnam.

ABSTRACT

The channels of the decay of Bottom mesons are deduced from a selection rule and the Lagrangians which are formed on the L⊗O(4) invariance and the principle of minimal structure. The estimation of the corresponding decay probabilities are considered.

## I. INTRODUCTION

From the recent information [21] of the decays of the Bottom mesons, it can be seen that the number of the observed exclusive channels up to now is very large. Really, for the $B^+$ there are 87 channels and for the $B^0$ there are 82 ones. This picture could be seen, as is discussed in section II, in comparing of the magnitudes of the decay probabilities of inclusive channels and the ones of corresponding detailed channels, contained in these.

The predictions and the evaluations of the exclusive decay channels of the B-mesons were made in the works [1] - [8], ... Generally, they are performed in framework of the Quark-Model. However, even with some modifications, actually the numbers of the theoretical channels really are small, in comparison with the above mentioned observed ones.

This word is a continue of some our previous papers and on the same principles as were used and will be presented briefly below. Here we would like to notice that the such principles seem to be effective for consideration of the problems of the decays of particles. This paper was performed with comparison with the data in [13], in which the number of observed exclusive channels is 79. In [21] the such number becomes 169 and all new channels are present in the theoretical predicted ones. More detailed consideration will be made in a note in the section V.

It is a necessarity to try to suggest that, because of the general sucesses of the Quark-Model for the problems of the Particle Physics, the following consideration could be hold as a some effective approximation of the last Model. If it is so and if the Quarks really exist inside of the Hadrons, then the corrections could be made in changing of the Hadrons by the corresponding quark composites. And then in the Feynman's diagrams a line of a meson should be changed by two corresponding quark- and antiquark-lines and a line of a baryon should be changed by three corresponding quark lines, etc...

We shall consider the problem of the decays of the Bottom mesons in using a selection rule and the Lagrangians formed on the principles of minimal structure. These principles were used in our previous papers [9], [10], [11]. (See III.1.1).

The selection rule is presented in the form

$$\Delta Q = \Delta I_3 = \Delta B = \Delta L_i = \Delta S_t = 0 \qquad (1.1)$$

where $Q$, $I_3$, $B$, $S_t$ are the electric charge, the third component of the isospin, the baryonic number, the leptonic number of the lepton i ($i = e, \mu, \tau$) and the total strangeness, respectively.

The rule express the conservation laws of the characteristic numbers when we take into account all particles participating in the decay processes: the hadrons as well as the leptons the photons and the spurions. The leptons, in our classification [12] have the following characteristic numbers: spin $\frac{1}{2}$, and



isospin $\frac{1}{2}$. The $e^-$, $\mu^-$, $\tau^-$ have $I_3 = -\frac{1}{2}$ and the leptonic numbers $L_i = 1$ ($i = e, \mu, \tau$), the $\nu_e$, $\nu_\mu$, $\nu_\tau$ have $I_3 = \frac{1}{2}$ and $L_i = 1$. The spurions in the free states are the unobservable particles. They were supposed in the Unified Field Theory of V. Heisenberg [14] and are the ones of the specific field operator deduced on the summetry of the Unifield Space [15] They have the spin 0 and the isospin $\frac{1}{2}$. The spurion $S_1$ has $I_3 = \frac{1}{2}$ and $S_t = -1$, the spurion $S_2$ has $I_3 = -\frac{1}{2}$ and $S_t = 1$. They are the neutral mesons and together with the other particles satisfythe generalized Gell-Mann-Nishijima Ralation:

$$Q = I_3 + \frac{B - L_i + S_t}{2} \qquad (1.2)$$

From the rule (1.1) in the most cases when we take into account only the hadrons , we shall obtain the "hadronic" selection rules $\Delta I_H = \frac{1}{2}$ , $\Delta Q_H = \Delta S_H$ etc. ... where the H is for a disignation of the hadrons. The $\Delta S_H \neq 0$ could be explained as a result of the existence of the spurions but they are unobservable.

The field operators which will be introduced into the Lagrangians are written in the Spectral Expansion form. They are the superpositions of the products of the usual and internal field operators (see (III.1)). The such operators are deduced from the Spectral Expansions of the field operators in a 8-dimensional Unified Space [16] and each term of these is of the L⊗O(4) invariance. The Spectral Expansion field operators lead to the particle group properties of the decay processes. It could be summarised as follows, each particle groupe having the indentical spin and isospin should be of the corresponding field operators presented in the Spectral Expansion form. And a consequense of these field operators is that, in the decay channels if a particle of a given particle groupe is present, the other particles of this particle groupe should be presented also. The such property could be seen in the decays of the heavy particles ( they have the capacity for the decays into the different particles in a particle group ), particulary we can see this property in the decay of $J/\Psi$ ( The decays with participation of the $\gamma$ have the similar ones, in which instead of $\gamma$ will be $\omega$, $\phi$,... The $\gamma$, $\omega$, $\phi$ are the particles of the particle group $I(J) = 0(1)$ [11], [13]).

The L⊗O(4) invariance form of the decay Lagrangians let us confirm the particles and the antiparticles in the decay channels. In the next consideration, in the section III, we shall show that the $D^+$ and $D^0$ are not the particles but they are the antiparticles ( the $D^-$ and $\bar{D}^0$ are the particles). And from this as a consequence we shall have a result that the decays with creation of the D-mesons could occur only in the second and higher approximations. Wile, although the K-mesons and D-mesons are included in a particle group $I(J) = \frac{1}{2}(0)$ the decays with creation of the K-mesons could occur in the first approximation.

In the section III we shall consider the problem of establishment of the decay Lagrangians and deduction of the detailed decay channels of the B-mesons.

In the section IV we shall discuss the magnitudes of the decay probabilities of above mentioned channels. Some suppositions of the coupling constants should be made in the end of the paper.

## II. SOME FEATURES OF THE EXPERIMENTAL DATA

The B-mesons have the spin 0 and the isospin $\frac{1}{2}$: $I(J^P)=\frac{1}{2}(0^-)$ The mass of the charged $B^{\pm}$ is 5277.6±1.4 Mev and of the neutral $B^0$ is 5279.4±15 Mev. The mean lifes of $B^{\pm}$ is $\tau = (11.8\pm1.1)\times10^{-13}$s and of $B^0$is $\tau_0 = \tau(0.44-2.05)$.

The B are the heavy mesons and so they can be disintegrated into many decay types and with many decay channels. Really, we can see in the data that, the charged B are disintegrated into $l_\nu$ hadrons with the probability (23.1±1.1)%, into $D^{\pm}$anything with the probability (17±6)% , into $D^0/\bar{D}^0$anything with the probability (3 ± 6)%, into $D^*(2010)^{\pm}$anything with the probability $(22\ ^{+8}_{-6})$% , into $D_s^{\pm}$anything with the probability (12.5 ± 3.5)%, into $K^{\pm}$anything with the probability (85 ± 11)%, into $K^0/\bar{K}^0$anything with the probability (63 ± 8)%, (the signs of the electric charges are not definited yet). While each detailed channel takes a very small value of probability. For



example, the decays $B^+\to K^+\rho^0$, $B^+\to K^0\pi^+$, $B^+\to \bar{D}^0\pi^+$, ... take the probabilities $<7\times10^{-5}$, $<9\times10^{-5}$, $(2.9\pm1.4)\times10^{-3}$, ... So the numbers of the detailed channels should be very large. They are around $10^2 - 10^3$.

In actual data we for each decay type have only some detailed decay channels . For example included in the decay type $B\to K^{\pm}$anything there are only 3 channels (as we shall prove, there are more than 100 channels).

Thus, as was presented , the most important parts of the detailed decays are not observed yet, and so, the deduction of the such detailed decay channels and the estimation of the corresponding decay probabilities are really necessary [13].

## III. CHANNELS OF THE DECAYS OF B-MESONS

### III.1 DECAYS INTO MESONS

Let us consider the decay of B-mesons into mesons . The B-mesons belong to the particle group $I(J) = \frac{1}{2}(0)$. So their field operators in the Spectral Expansion, whichwas mentioned above, should have the form

$$\varphi(x)\chi(X) = \int_0^\infty dm^2\langle J_1, J_2|m^2\rangle \varphi_{J_1}(m^2,x)\chi_{J_2}(m^2,X)$$

where $\varphi_{J_1}(m^2,x)$ and $\chi_{J_2}(m^2,X)$ are the external (usual) complex pseudo scalar field operator and the internal spinor field operators, respectively [16].

This and the other field operators of the other particle groupes in Spectral Expansion form will be introduced into the Lagrangians. Then , using the S-matrix formalism in Unified Space [17] we shall have the matrix elements in which the such field operators in momentum representation will be presented. And for the initial and final states, in corresponding to the postulate of the free particles (the 8-dimensonal Space is divided into two invariant subspaces, Minkowskian and Internal) [17] we shall select the states with the given masses and of the observed particles. For this we can use the mass orthoganality $\langle m^2/m^2_{obs.}\rangle = \delta(m^2 - m^2_{obs.})$ and with this we can extract the states corresponding to the experimental facts [9] - [11].

### III.1.1 THE DECAY LAGRANGIAN

As for the decays of other particles [9], [10], and [11] we shall establish the Lagrangians for the decay of B-mesons on the following principles:

1. Invariance on the $L\otimes O(4)$ group.
2. Minimal structure - The number of the field operators introduced into the Lagrangians should be minimal, enough for the establishment of the invariance.
3. The field operators are of the form of Spectral Expansion - The such operator should be for all particles of the corresponding particle group, determined by a given $I(J)$.

For the case of decay into mesons we shall use the following denotation :

The field operator $E^{(n)}(x)I^{(\alpha)}(X)$ is the total field operator in Spectral Expantion in which $E^{(n)}(x)$ is an external n-rank tensor field operator and $I^{(\alpha)}(X)$ is an internal $\alpha$-rank tensor field operator. Corresponding to these we shall denote $\partial_{|n|}$, the n-order derivation on the usual variables and $\partial_{|\alpha|}$, the $\alpha$-order derivation on the internal variables.

With these denotations we can write the Lagrangian for the decay of B-mesons into the mesons as follows

$$L_1 = \overset{*}{\varphi}(x)\overset{*}{\chi}(X)\chi(X) \sum_{j=0}^{4} \sum_{n=0}^{4} \sum_{\alpha=0}^{1} E^{(j)}(x) G^{j(\lambda)}_{n\alpha}\, \partial_{|n-j|} E^{(n)}(x)\, \partial_{\alpha} I^{\alpha}(X) + h.c \tag{3.1}$$

where $G^{j(\lambda)}_{n\alpha}$ are the constants. The index $\lambda$ is for the different values of coupling constants in the cases of creation of K, S and D : $\lambda$ = K, S and D . This difference will be discussed in III.14 and in IV. The summation over j, $0 \le j \le 4$, is taken in relating to the actual observed strange mesons (K and D). The



n and $\alpha$ are taken also in accordance with the actual data of the nonstrange ( normal ) mesons. The tensor field operators, external and internal, could be either complex or real.

### III.1.2 DECAYS WITH CREATION OF THE K-MESON FAMILY PARTICLES

Let us consider now the decays with creation of the K-family mesons (particles of the particle groups $\frac{1}{2}(n)$). In the first approximation, using the Lagrangian (3.1), the mass orthoganality and the selection rule (1.1) we can deduce the following decay channels

$B^+ \to$ [ K(493), $K^*_0(1430)$; $K^*(892)$, $K_1(1270)$, $K^*(1370)$, $K_1(1400)$, $K^*(1680)$; $K^*_2(1430)$, $K_2(1770)$; $K^*_3(1780)$; $K^*_4(2045)$ $]^+ \times$
[ $\eta(549)$, $\eta'(958)$, $f_0(975)$, $\eta(1295)$, $f_0(14)0)$, $\eta(1440)$, $f_0(1590)$, $\chi_{c0}(3415)$; $\omega(783)$, $a_0(980)$, $\phi(1020)$, $h_1(1170)$, $f_1(1285)$, $\omega(1390)$, $f_1(1420)$, $f_1(1510)$, $\omega(1600)$, $\phi(1680)$, $\eta_c(2980)$, $J/\psi(3097)$, $\chi_{c1}(3510)$, $\Psi(3685)$, $\Psi(3770)$?, $\Psi(4040)$?, $\Psi(4160)$?, $\Psi(4415)$?, $\gamma$; $f_2(1290)$, $f'_2(1525)$, $f_2(1720)$, $f_2(2010)$, $f_2(2300)$, $f_2(2340)$, $\chi_{c2}(3555)$; $\omega_3(1670)$, $\phi_3(1850)$; $f_4(2050)$ $]^0$

$B^+ \to$ [ K(493), $K^*_0(1430)$ ; $K^*(892)$, $K_1(1270)$, $K^*(1370)$, $K_1(1400)$, $K^*(1680)$; $K^*_2(1430)$, $K_2(1770)$; $K_3(1780)$; $K^*_4(2045)$ $]^{\overset{+}{0}} \times$
[ $\pi(139)$, $a_0(980)$, $\pi(1300)$; $\rho(770)$, $b_1(1235)$, $a_1(1260)$, $\rho(1450)$, $\rho(1700)$; $a_2(1320)$, $\pi_2(1670)$; $\rho_3(1690)$ $]^{\overset{0}{+}}$ (3.2)

Where we have made a denotation:

$B^+ \to (a, b, \ldots)(A, B, \ldots) = B^+ \to aA,\ B^+ \to aB,\ B^+ \to bA,\ B^+ \to bB, \ldots$

For convenience in presentation we rewrite (3.2) in the form

$$B^+ \to [K]^+ [I_0]^0,\quad B^+ \to [K]^{\overset{+}{0}} [I]^{\overset{0}{+}} \tag{3.2'}$$

then we can write the decay of $B^-$ and $B^0$ with creation of K-mesons as follows

$B^- \to [\mathcal{K}]^- [I_0]^0, \; B^- \to [\bar{\mathcal{K}}]^{\bar{0}} [\bar{I}]^{\bar{0}}$

$B^0 \to [\mathcal{K}]^0 [I_0]^0, \; B^0 \to [\mathcal{K}]^+ [I]^-$

**and**

$\bar{B}^0 \to [\bar{\mathcal{K}}]^0 [\bar{I}_0]^0, \; \bar{B}^0 \to [\bar{\mathcal{K}}]^{\bar{0}} [\bar{I}]^{\bar{0}}$

The $[\mathcal{K}]$ will be called the K-family particles, $I(J) = \frac{1}{2}(n)$. The $[I_0]$ will be called the $I_0$-family particles, $I(J) = 0(m)$ and the $[I]$ will be called the I-family particles, $I(k) = 1(k)$, where n, m, k = 0, 1, 2,...

In the second approximation, with exchange of one virtual anomalous meson (meson having $S_t \neq 0$) we have the decay channels

$$B^+ \to [\mathcal{K}]^+ [I]^+ [I]^-$$
$$B^+ \to [\mathcal{K}]^+ [I + I_0]^0 [I + I_0]^0$$
$$B^+ \to [\mathcal{K}]^0 [I]^+ [I + I_0]^0$$
$$(3.3)$$
$$B^0 \to [\mathcal{K}]^0 [I]^+ [I]^-$$
$$B^0 \to [\mathcal{K}]^+ [I]^- [I + I_0]^0$$
$$B^0 \to [\mathcal{K}]^0 [I + I_0]^0 [I + I_0]^0$$

where we have introduced a denotation $[A] \to [B][C{+}D] \equiv A \to BC, A \to BD$.

## III 1.3 DECAYS INTO NORMAL MESONS

We consider now the decays of B-mesons in which the observed particles in the decay productions are the normal ($S_t = 0$) mesons . We shall also use the Lagrangian (3.2) . It is clear that in the first approximation the such decays can not occur. And in the second approximation, with exchange of one virtual meson of the particle groups $\frac{1}{2}(J)$, we have the following decay channels



$$B^+ \to [I]^+ [I + I_0]^0 S_z \qquad (3.4)$$
$$B^0 \to [I]^0 [I + I_0]^0 S_z$$

Where $S_z$ is an unobservable spurion, [11], [15]

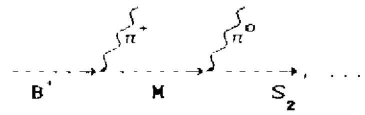


Fig.1 The decay $B^+ \to \pi^+\pi^0 S_z$ with exchange of a virtual meson of the particle group $\frac{1}{2}$ (J)
The time direction is left-right

## III.1.4 DECAYS INTO ANOMALOUS MESONS

Let us consider the decays of the B-mesons into anormalous mesons .

In the groups of the anomalous mesons the D-mesons have some conventional problem relating to the particle-antiparticle property, about which we shall consider now.

The D-mesons have the spin 0 and the isospin $\frac{1}{2}$ . They belong to the particle group $0(\frac{1}{2})$, that of the B-mesons and also of the K-mesons and the spurions. So it can be thought that the decay channels with creation of the D-mesons should be identifical to the ones with creation of the K-mesons. However, on our viewpoint, betweem the K-mesons and the D-mesons there is a radical difference of the particle-antiparticle property : the $K^+$ and $K^0$ are particles, while the $D^+$ and $D^0$ are the antiparticles. And then the $D^-$ and $\bar{D}^0$ are particles.

It is that the $K^+$ and $K^0$ have the $I_3 = \frac{1}{2}$ and $I_3 = -\frac{1}{2}$ and their total strangeness $S_t = 1$; The $D^-$ and $\bar{D}^0$ have the $I_3 = -\frac{1}{2}$ and $I_3 = \frac{1}{2}$ and their total strangeness $S_t = -1$.

As is well known, in the experimental data together with the D(1864)-mesons there are the D(2010), $D_z(2420)$ which have the spin 1 and the isospin $\frac{1}{2}$ and the $D^*_z(2460)$ having the spin 2 and isospin $\frac{1}{2}$ . And in similarity to the case of K-mesons, we shall consider these particles as the particles of the D-family, and suppose that they have the same particle-antiparticle property as the D(1864) : the $D(2010)^-$, $\bar{D}(2010)^o$, $D_1(2430)^-$, $\bar{D}_1(2430)^o$, $D_2(2460)^-$ and $\bar{D}_2(2460)^o$ are the particles ; the $D(2010)^+$, $D(2010)^o$, $D_1(2430)^+$, $D_1(2010)^o$, $D_2(2460)^+$ and $D_2(2460)^o$ are the antiparticles.

Two K- and D- particle families as the other mesons, satisfy the Gell-Mann-Nishijima relation

$$Q = I_3 + \frac{S_1}{2} . \tag{3.5}$$

For the Lagrangian, because the D-family mesons and the K-family mesons are of the particle group $\frac{1}{2}(J)$, we can see that (3.2) could be used also for the decays of B-mesons with creation of the D-mesons.

Now let us consider the channels with creation of the anomalous mesons.

a. Decays into particles of the K-family mesons

In the first approximation the such decays are forbidden, and in the second approximation we have the following decay channels:

$$\begin{array}{ll} B^+ \rightarrow [\mathcal{K}]^+ [\bar{\mathcal{K}}]^o S_2 & B^+ \rightarrow [\mathcal{K}]^+ [\mathcal{K}]^+ [\mathcal{K}]^- \\ B^+ \rightarrow [\mathcal{K}]^+ [\mathcal{K}]^o \bar{S}_2 & B^+ \rightarrow [\mathcal{K}]^+ [\mathcal{K}]^o [\bar{\mathcal{K}}]^o \\ B^o \rightarrow [\mathcal{K}]^o [\bar{\mathcal{K}}]^o S_2 & B^o \rightarrow [\mathcal{K}]^+ [\mathcal{K}]^o [\mathcal{K}]^- \\ B^o \rightarrow [\mathcal{K}]^+ [\mathcal{K}]^- S_2 & B^o \rightarrow [\mathcal{K}]^o [\mathcal{K}]^o [\bar{\mathcal{K}}]^o \end{array} \tag{3.6}$$

b. Decays into particles of K- and D-meson families *

The decays are forbidden in the first approximation, and in the second approximation we have:

* From (3.7), as well as from (3.10), (3.12), (3.14), ... it is easy to see that the $D^+$ and $D^o$ are the antiparticles - The external field operators of the spurions are real.



$$\begin{array}{ll} B^+ \rightarrow [\mathcal{K}]^+ [\mathcal{D}]^o S_1 & B^o \rightarrow [\mathcal{K}]^o [\mathcal{D}]^o S_1 \\ B^+ \rightarrow [\mathcal{K}]^o [\mathcal{D}]^+ S_1 & B^o \rightarrow [\mathcal{K}]^+ [\mathcal{D}]^- \bar{S}_1 \\ B^+ \rightarrow [\mathcal{K}]^+ [\bar{\mathcal{D}}]^o \bar{S}_1 & \end{array} \tag{3.7}$$

where $[\mathcal{D}]$ = [D(1966), $D^*(2010)$, $D_1(2420)$, $D_2^*(2460)$]

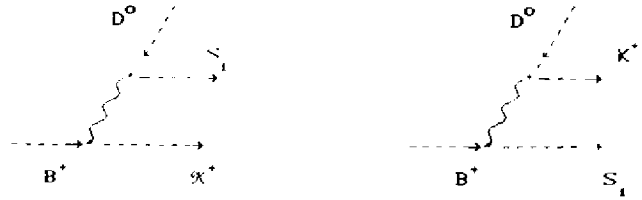


Fig.2 Decays of $B^+$ into K-family and D-family particles

c. Decays into particles of D-meson family

The first allowed channels, as in the previous cases, are in the second approximation. They are:

$$\begin{array}{l} B^+ \rightarrow [\mathcal{D}]^+ [\bar{\mathcal{D}}]^o S_2 \\ B^o \rightarrow [\mathcal{D}]^o [\bar{\mathcal{D}}]^o S_2 \\ B^o \rightarrow [\mathcal{D}]^+ [\mathcal{D}]^- S_2 \end{array} \tag{3.8}$$

d. Decays into particles of K-family and $D_s$-family mesons

It can be seen that only from the third approximation we can have the first nonzero decay probabilities. And the channels in this approximation are:

$$\begin{array}{l} B^+ \rightarrow [\mathcal{K}]^o [\bar{\mathcal{D}}_s]^+ \bar{S}_2 S_1 \\ B^o \rightarrow [\mathcal{K}]^+ [\mathcal{D}_s]^- S_2 \bar{S}_1 \\ B^o \rightarrow [\mathcal{K}]^- [\mathcal{D}_s]^+ \bar{S}_2 S_1 \end{array} \tag{3.9}$$

Where $[\mathcal{D}_s]$ = [$D_s(1968)$, $D_s^*(2110)$, $D_{s_1}(2535)$]

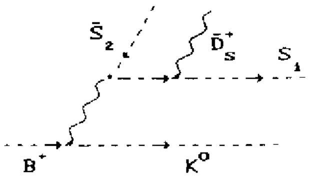


Fig.3 Decays of B-mesons into K-family and $D_s$-family mesons

e. Decays into particle of D-family and $D_s$-family mesons

We have in the first approximation the following decay channels:

$$B^+ \rightarrow [\bar{\mathcal{D}}]^0 [\mathcal{D}_s]^+ \qquad B^0 \rightarrow [\mathcal{D}]^- [\mathcal{D}_s]^+ \qquad (3.10)$$

f. Decays into particles of $D_s$-family mesons

Finally , we have the following decays of $B^0$-meson into the $D_s$-mesons, in the second approximation

$$B^0 \rightarrow [\mathcal{D}_s]^+ [\mathcal{D}_s]^- S_2 \qquad (3.11)$$

**III.1.5 DECAYS INTO D AND NORMAL MESONS**

In the third approximation we have the decays into the D-family particles and the normal mesons. They are

$$B^+ \rightarrow [\bar{\mathcal{D}}]^0 [I]^+ \bar{S}_1 S_2 \qquad (3.12)$$

**III.1.6 DECAYS INTO $D_s$-FAMILY MESONS AND NORMAL MESONS**

The decays of B-mesons into $\mathcal{D}_s$ and normal mesons occur firstly in the second approximation and they are

$$B^+ \rightarrow [\mathcal{D}_s]^+ [I + I_0]^0 S_1 \qquad B^0 \rightarrow [\mathcal{D}_s]^+ [I]^- S_1 \qquad (3.13)$$

**III.1.7 DECAYS IN HIGHER APPROXIMATIONS**

In the fourth approximation we have the decay channels of the types



$$\begin{aligned} B^+ &\rightarrow [\mathcal{D}]^- [I]^+ [I]^+ \bar{S}_1 S_2 \\ B^+ &\rightarrow [\bar{\mathcal{D}}]^0 [I]^+ [I]^0 \bar{S}_1 S_2 \\ B^+ &\rightarrow [\bar{\mathcal{D}}]^0 [I]^+ [I_0]^0 \bar{S}_1 S_2 \\ B^0 &\rightarrow [\bar{\mathcal{D}}]^0 [I]^+ [I]^- \bar{S}_1 S_2 \\ B^0 &\rightarrow [\bar{\mathcal{D}}]^- [I]^+ [I]^0 \bar{S}_1 S_2 \\ B^0 &\rightarrow [\bar{\mathcal{D}}]^- [I]^+ [I_0]^0 \bar{S}_1 S_2 \end{aligned} \qquad (3.14)$$

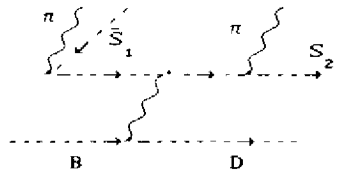


Fig.4 Decays of B-mesons into D-family and nornal mesons in the 4-th approximation.

In the higher approximations, we shall have the channels with the creation of the more large numbers of the mesons. For example in the 5-th approximation we have

$$B^+ \rightarrow D^*(2010)^- \pi^+ \pi^+ \pi^0 \bar{S}_1 S_2$$

and of course the decay probability of this channel sould be very small. However from the data [13] we can see that this decay occuring with the probability (4.3±2.9)%. At the same time, for example the decay with creation of two pions $B^+ \rightarrow D^*(2010)^- \pi^+ \pi^+$ was observed with the probability $(2.5 \pm 1.5) \times 10^{-3}$ . This fact leads to the idea to explanation of the decays with creation of many pions on the supposition of two-stage decays [11].

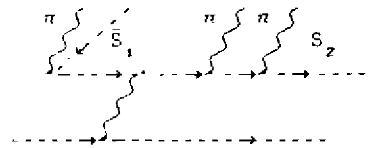


Fig.5 Decays of B-mesons into D-family and nornal mesons in the 5-th approximation.

In (3.5) - (3.9) and in (3.11) - (3.14) the decay channels contain the spurions $S_1$, $S_2$ and their antispurions $\tilde{S}_1$, $\tilde{S}_2$. The spurion $S_1$ has $S_t = -1$ and $I_3 = \frac{1}{2}$, the $S_2$ has $S_t = 1$ and $I_3 = -\frac{1}{2}$. In the free (final) states the spurions are unobservable [15], so we have a result : In the channel with participation of $S_1$ we have the rule $\Delta S_{Ht} = 1$ and $\Delta I_{H3} = -\frac{1}{2}$, with participation of $\tilde{S}_1$ we have the rule $\Delta S_{Ht} = -1$ and $\Delta I_{H3} = \frac{1}{2}$, with participation of $S_2$ we have the rule $\Delta S_{Ht} = -1$ and $\Delta I_{H3} = \frac{1}{2}$ and with participation of $\tilde{S}_2$ we have the rule $\Delta S_{Ht} = 1$ and $\Delta I_{H3} = -\frac{1}{2}$. Then if we consider a channel with participation of $\tilde{S}_2 S_1$, for example in (3.9), we shall have the rule $\Delta S_{Ht} = 2$ and $\Delta I_{H3} = -1$, if we have a channel with $\tilde{S}_1 S_2$ , as in (3.12), we shall have the rule $\Delta S_{Ht} = -2$ and $\Delta I_{H3} = 1$, etc... The H is for a designation of the hadrons.

**III.1.8 TWO-STAGE DECAYS**

Let us return to the decays of (3.12). From these we have

$$B^+ \to D^*(2010)^- \pi^+ [I]^+ \tilde{S}_1 S_2$$

in which the decay $B^+ \to D^*(2010)^- \pi^+ \pi^+ \tilde{S}_1 S_2$ is contained . The particles in the square parenthese are the ones of the particle group I(J) = 1(J) of the normal mesons . The most stable of these are the $\pi$-mesons and , the other mesons of this particle group are very unstable. From the data we can see that some of the last are desintergated into two $\pi$-mesons and with the large values of probability . We take some examples : $\rho(770) \to 2\pi$ with prob. 100% ; $\rho(1450) \to 2\pi$ , seen ; $\rho(1690) \to 2\pi$ with prob. ~ 23%, $f_2(1270) \to 2\pi$ with prob. ~ 85% ; $f_2'(1525) \to 2\pi$ with prob 8%; $f_2(1720) \to 2\pi$ with prob. ~ 4%; $f_4(2050) \to 2\pi$ with prob. ~ 17% etc... A particular remark which could be made here is that , the absolute values of the decay probabilities of these mesons are very large: the full widths of the $\rho(770)$, $\rho(1450)$, $\rho(1690)$, $f_2(1270)$, $f_2'(1525)$, $f_2(1720)$, $f_4(2050)$, ... respectively are 149 Mev, 237 Mev, 215 Mev, 185 Mev, 76 Mev, 138 Mev, 203 Mev, ...

And the two-stage decays can give us an explanation for the probabilities of the decays $B^+ \to D^*(2010)^- \pi^+ \pi^+ \pi^0$ , $B^+ \to D^*(2010)^0 \pi^+ \pi^0 \pi^0$ etc... Really, as was mentioned above, experimentally these probabilities are relatively larger than the probabilities of the decays of the type $B^+ \to D^*(2010)^0 \pi^+$ and $B^+ \to D^*(2010)^- \pi^+ \pi^+$ (They are of the probabilities of $10^{-3}$ [13]). And for these we can not explain in using the results in 5-th approximation in III.1.7. We can consider the decays with creation of $D^*(2010)$ into three pions as the decays in two stages. In the first stage there are the decay into $D(2010)\pi$ and an unstable meson of the particle group 1(J) and in the second stage the such unstable meson again are disintegrated into two pions.

Of course the last explanation have the signification if the constants $G^{j(D)}_{n\alpha}$ in (3.1) should have the large magnitudes. And as we shall prove in the section IV, the coupling constants related to these take the values about 0.8.

Here we would like to emphazise that the probabilities become large (~$10^{-2}$) relate to the large number of the different virtual mesons which are exchanged in the different Feynman's diagrams of a same type (see Lagrangian (3.1)).

We have discussed the problem with the $D^*(2010)$, clearly the same discussion should be valid for the other particles of D-family particles.

The discussion is also applied for the decays of B-mesons into K-mesons and two pions. This should be made in using the first stage decays in the first approximation, in III.1.2.

Theoretically we can generalize the consideration for the cases of the creation of the larger numbers of the pions, however really the such cases should occur with the neglected decay probabilities.

**III.1.9 DECAY WITH CREATION OF THE BARYONS**

We consider now the decays of B-mesons with creation of the baryons. In approach to the field theory in Unified Space [18] there are two sorts of the baryons: the normal baryons and the anormalous baryons.

The normal baryons are the ones which much have the half-integral spins and half-integral isospins and satisfy the Gell-mann-Nishijima's relation with the total strangeness $S_t = 0$. The other baryons having $S_t \neq 0$ are called the anormalous ones.

Related to these particles we shall have the problems with the usual and internal spinor field operators of the high ranks. And as is well known there are some ways to formulation of the such field operators. Below we shall use the formulation of W. Rarita, J. Schwinger, A.S. Davuidov and I.E. Tamm [19]. According to this we can present the spinor field function of third rank in the form, in which two spinor index $\alpha\beta$ equivalent to a vector index. The such spinor field function also satisfy the Dirac's equation

$$(\hat{p} - m)\,\Psi_\mu = 0$$

and the a complementary condition

$$\gamma^\mu \Psi_\mu = 0$$

We shall generalize this formulation for the case of higher rankof the field functions . And we shall denote the spinor field function of the rank 2J+1 (J is the spin) by $\Psi_{(J)}$ in which J is the tensor rank.

The such generalization could be made for the internal spinor field functi n. For the first rank the internal spinor field function satisfies the equation [18]

$$(\hat{P} - m)\,\chi(X) = 0$$

where $\hat{P} = \sum_{\alpha=1}^{4} \Gamma^\alpha P_\alpha$ , the $P_\alpha$ are the components of the internal momenta, and the matrices $\Gamma^\alpha$ relate to the Dirac's matrices as follows $\Gamma^4 = \gamma^0$, $\vec{\Gamma} = i\vec{\gamma}$. So we can represent the internal spinor field function of the rank 2I+1 (I is the isospin) in the form $\chi_{(I)}(X)$ in which I just is the tensor rank.

Accounting the principles from which we have used for the case of the decays of B-mesons, with creation of the mesons, we can establish the following Lagrangian for our present case



$$L_2 = \overset{*}{\varphi}(x)\overset{*}{\chi}(X)\chi(X) \sum_{j=0}^{4} \sum_{n=0}^{4} \sum_{\substack{a,b \\ a+b=n}} \sum_{\substack{\lambda,\delta \\ \lambda+\delta=\alpha}} G^{j}_{nab,\alpha\lambda\delta} \times E^{j}(x) \times \tag{3.15}$$

$$\times\ \partial_{|n-j|} \bar{\Psi}_a(x)\Psi_b(x)\ \partial_{|\alpha|} [\overset{*}{\chi}_\lambda(X)\ \chi_\delta(X) + $$

$$+ a_s \overset{*}{I}{}^{\lambda}(X) I^{\delta}(X)] + \text{h.c.}$$

where $G^{j}_{nab,\alpha\lambda\delta}$ and $a_s$ are the constants . In the last square parenthese the first terms relate to the creation of the nor-baryons (and the Ξ-family particles) and the second terms are of the creation of the anormalous (strange, charmed, ...) baryons

a. Decays with creation of the normal baryons

As in the case of the decays into mesons, we make a denotation:

$$[N] = [N_{\frac{1}{2}}(938,\ 1440,\ 1535,\ 1650,\ 1710) + \Xi_c +$$
$$N_{\frac{3}{2}}(1520,\ 1700,\ 1720) + N_{\frac{5}{2}}(1675,\ 1680) + N_{\frac{7}{2}}(2190) +$$
$$+\ N_{\frac{9}{2}}(2150\text{-}2300,\ 2250) + N_{\frac{11}{2}}(2600)]\ ,$$

where the index J at $N_J$ denotes the value of the spin of the particle.

Analogously, we shall have a denotation for the Δ-baryons

$$[\Delta] = [\Delta_{\frac{1}{2}}(1620,\ 1900,\ 1910) + \Delta_{\frac{3}{2}}(1232,\ 1700,\ 1920) +$$
$$+\ \Delta_{\frac{5}{2}}(1905,\ 1930) + \Delta_{\frac{7}{2}}(1950) + \Delta_{\frac{11}{2}}(2420)]$$

Using the Lagrangian (3.15) and the selection rule (1.1) we shall have the following decay channels in the first approximation:

$$B^{+} \to [N]^{+}[\bar{N}]^{0}S_z \qquad B^{+} \to [\Delta]^{++}[\bar{\Delta}]^{-}S_z$$

$$B^{0} \to [N]^{0}[\bar{N}]^{0}S_z \qquad B^{+} \to [\Delta]^{+}[\bar{\Delta}]^{0}S_z$$

$$B^{+} \to [\bar{\Delta}]^{+}[\Delta]^{0}S_z$$

$$B^{+} \to [\Delta]^{++}[\bar{N}]^{-}S_z$$

$$B^{+} \to [\Delta]^{+}[\bar{N}]^{0}S_z \qquad B^{0} \to [\Delta]^{++}[\bar{\Delta}]^{--}S_z \qquad (3.16)$$

$$B^{+} \to [\bar{\Delta}]^{0}[N]^{+}S_z \qquad B^{0} \to [\Delta]^{+}[\bar{\Delta}]^{-}S_z$$

$$B^{+} \to [\bar{\Delta}]^{+}[N]^{0}S_z \qquad B^{0} \to [\bar{\Delta}]^{+}[\Delta]^{-}S_z \qquad (*)$$

$$B^{0} \to [\Delta]^{0}[\bar{\Delta}]^{0}S_z$$

$$B^{0} \to [\Delta]^{+}[\bar{N}]^{-}S_z$$

$$B^{0} \to [\Delta]^{0}[\bar{N}]^{0}S_z$$

$$B^{0} \to [\bar{\Delta}]^{0}[N]^{0}S_z$$

Here we can make a notice that the baryons of spin $S = \frac{11}{2}$ could not appear in the decays. This relates to the fact that in the Lagrangian (3.15) the number a and b are in the relation $a+b = n$, $n \le 4$.

## b. Decays with creation of the strange mesons and normal baryons

The Lagrangian (3.15) besides the above considered decays with creation of the normal baryons (and an unobserved spurion $S_z$) could give the decays with creation of the such baryons and the neutral mesons of the K-family. Really, the spurion $S_z$ has the $I_3 = -\frac{1}{2}$ and the $S_t = 1$ and the neutral particles of K-family have the same characteristic numbers, so the decay channels for the present considered case could be obtained by using the above deduced channels (3.16) and by the change $S_z \to [\mathcal{K}]^{0}$ (of course in this change, instead of the real external field operator of the spurions, we shall take the complex external field operator of the $\mathcal{K}$-family particles).

## c. Decays with creation of the anomalous baryons

The anormalous baryons which were observed until now are the ones of the $\Lambda$-, $\Sigma$-, $\Xi$-, $\Omega$-, $\Lambda_c^{+}$- and $\Sigma_c$- families. We can arrange these particle groups as follows



$$[\Lambda] = [\Lambda_{\frac{1}{2}}(1115,\ 1405,\ 1600,\ 1670, 1800,\ 1810) + \Lambda_{\frac{3}{2}}(1520,\ 1690,\ 1890) + \Lambda_{\frac{5}{2}}(1820,\ 1830,\ 2110) + \Lambda_{\frac{7}{2}}(2100) + \Lambda_{\frac{9}{2}}(2350)]$$

$$[\Sigma] = [\Sigma_{\frac{1}{2}}(1189,\ 1660,\ 1750) + \Sigma_{\frac{3}{2}}(1585,\ 1670,\ 1940) + \Sigma_{\frac{5}{2}}(1775,\ 1915) + \Sigma_{\frac{7}{2}}(2030)]$$

$$[\Xi] = [\Xi_{\frac{1}{2}}(1315) + \Xi_{\frac{3}{2}}(1530) + \Xi_{\frac{5}{2}?}(2030) + \Xi_{?}(1690,\ 1950)]$$

$$\Omega^{-} = [\Omega^{-}_{\frac{3}{2}}(1672) + \Omega_{?}(2250)]$$

$$\Lambda_c^{+} = \Lambda^{+}_{c\frac{1}{2}}(2285)$$

$$\Sigma_c = \Sigma_{c\frac{1}{2}}(2455)$$

where we do not consider the $\Xi_c$-baryons because these are of a doublet ($\Xi_c^{+}$ and $\Xi_c^{0}$ ) which satisfies the generalized Gell-mann-Nishijima (1.2) with $S_t = 0$, and we have arranged the $\Xi$-baryons into the N-family.

Using the Lagrangian (3.15) and the selection rule (1.1) we shall have in the first approximation the following decay channels with creation of the anormalous baryons

$$B^{+} \to [\bar{\Lambda}]^{0}[\Lambda]^{0}S_z \qquad B^{0} \to [\Delta]^{0}[\bar{\Sigma}]^{0}S_z \qquad B^{0} \to [\bar{\Sigma}]^{0}[\Sigma]^{0}S_z$$

$$B^{+} \to [\bar{\Lambda}]^{0}[\Sigma]^{+}S_z \qquad B^{+} \to [\bar{\Sigma}]^{0}[\Sigma]^{+}S_z \qquad B^{0} \to [\bar{\Sigma}]^{+}[\Sigma]^{-}S_z \qquad (3.17)$$

$$B^{0} \to [\bar{\Lambda}]^{0}[\Sigma]^{0}S_z \qquad B^{+} \to [\Sigma]^{0}[\Sigma]^{+}S_z \qquad B^{0} \to [\Sigma]^{+}[\bar{\Sigma}]^{-}S_z$$

The decays of the types $[\Xi][\Sigma]$ and $[\Xi][\Lambda]$ are forbidden , in this first approximation.

Now we consider the decays into two particles of the $\Xi$-family. We have

$$B^+ \rightarrow [\Xi]^+ [\bar{\Xi}]^0 S_2$$
$$B^0 \rightarrow [\Xi]^+ [\Xi]^- S_2 \qquad (3.18)$$
$$B^0 \rightarrow [\Xi]^0 [\bar{\Xi}]^0 S_2$$

The decays with creation of the $\Omega^-$ are the following ones

$$B^0 \rightarrow [\bar{\Omega}]^+ [\Omega]^- S_2 \qquad (3.19)$$

The $\Lambda_c^+$ and $\Sigma_c$, according to our classification, are the mesons having the total strangeness $S_t = 1$ and the allowed channels with creation of these particles are

$$B^0 \rightarrow \Lambda_c^+ \bar{\Lambda}^- S_2 \qquad B^+ \rightarrow \Sigma_c^{++} \bar{\Lambda}_c^- S_2$$
$$B^0 \rightarrow \Sigma_c^+ \bar{\Lambda}_c^- S_2$$
$$B^+ \rightarrow [\bar{\Lambda}]^0 \Sigma_c^+ S_1$$
$$B^0 \rightarrow [\bar{\Lambda}]^0 \Sigma_c^0 S_1 \qquad B^+ \rightarrow \Sigma_c^{++} \bar{\Sigma}_c^- S_2$$
$$B^+ \rightarrow \Sigma_c^{++} [\bar{\Sigma}]^- S_1 \qquad B^+ \rightarrow \Sigma_c^+ \bar{\Sigma}_c^0 S_2$$
$$B^+ \rightarrow [\bar{\Sigma}]^0 \Sigma_c^+ S_1 \qquad (3.20)$$
$$B^0 \rightarrow [\bar{\Sigma}]^- \Sigma_c^+ S_1 \qquad B^0 \rightarrow \Sigma_c^{++} \bar{\Sigma}_c^{--} S_2$$
$$B^0 \rightarrow [\bar{\Sigma}]^0 \Sigma_c^0 S_1 \qquad B^0 \rightarrow \Sigma_c^+ \bar{\Sigma}_c^- S_2$$
$$B^0 \rightarrow \Sigma_c^0 \bar{\Sigma}_c^- S_2$$

### III.1.10 DECAYS WITH CREATION OF THE LEPTONS

We consider now the decays with creation of the leptons. For this we shall consider a Lagrangian of the structure of (3.2) and (3.15) and with some modification in order to have the relation to the leptonic currents . The leptonic currents in our theory approach have the forms[11]

Charged currents

$$J^{\mu}(x,X) = \bar{\Psi}_{\nu_l}(x)\gamma^{\mu}(1+\gamma^5)\ \Psi_l(x)\overset{*}{\chi}_{\nu_l}(X)\chi_l(X) \qquad (3.21)$$

Neutral currents

$$K^{\nu}(x,X) = \bar{\Psi}_{l,\nu_l}(x)\gamma_{\mu}(1+\gamma^5)\ \Psi_{l,\nu_l}(x)\overset{*}{\chi}_{l,\nu_l}(X)\chi_{l,\nu_l}(X) \qquad (3.22)$$



in which the total field functions $\Psi(x)\chi(X)$ are presented in the Spectral Expansion form. The l and $\nu_l$ denote leptons and their corresponding neutrino ($l = e, \mu, \tau$)

The Lagrangian could be written in the form

$$L_3 = \overset{*}{\varphi}(x)\overset{*}{\chi}(X)\chi(X) \sum_j E^{(j)}(x) G_l^j\ \partial_{|j-1|}[J(x,X) + \varkappa_l K(x,X)] + h.c. \qquad (3.23)$$

where $G_l^j$ and $\varkappa_l$ are the constants and $\varkappa_l$ relating to the neutral currents, will be supposed to be small x < 1.

Using the last Lagrangian and the selection rule (1.1) we shall have the following decay channels in the first approximation

$$B^+ \rightarrow [\mathcal{K}]^0 [l^+\nu_l] \qquad B^0 \rightarrow [\mathcal{K}]^+ [l^-\bar{\nu}_l]$$
$$B^+ \rightarrow [\mathcal{K}]^+ [l^+l^-] \qquad B^0 \rightarrow [\mathcal{K}]^0 [l^+l^-] \qquad (3.24)$$

In the same approximation we shall have the channels

$$B^+ \rightarrow l^+\nu_l\ S_2$$
$$B^0 \rightarrow l^+l^-\ S_2 \qquad (3.25)$$

In the second approximation we have

$$B^+ \rightarrow \bar{\mathcal{D}}^0 l^+\nu_l \bar{S}_1 S_2 \qquad B^0 \rightarrow \mathcal{D}^- l^+\nu_l \bar{S}_1 S_2 \qquad (3.26)$$

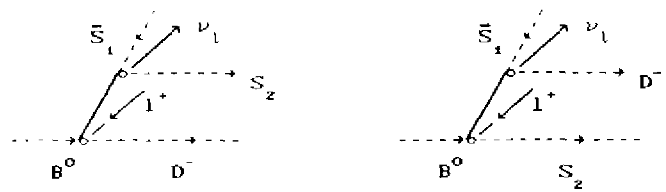


Fig.6 Semileptonic decays of B-meson in the second approximation

### III.1.11 DECAYS RELATED TO THE INTERFERENCE TERMS OF $L_1$, $L_2$ AND $L_3$

The total Lagrangian for the decays of B-mesons should be the summation of $L_1$, $L_2$, $L_3$. We have considered the interference terms in each Lagrangian $L_i$ (i=1,2,3) and now let us consider the interference terms between these .

We have the following channels in considering $L_1$ and $L_2$

$$B^+ \rightarrow [I]^+\{[N]^{+,0}[\bar{N}]^{-,0} + [\Delta]^{++,+,0,-}[\bar{\Delta}]^{--,-,0,+} +$$
$$[N]^+[\bar{\Delta}]^- + [\bar{N}]^-[\Delta]^+\}S_2 \equiv [I]^+[B_1]^0 S_2$$

$$B^+ \rightarrow [I+I_0]^0\{[N]^+[\bar{N}]^0 + [\Delta]^{++,+}[\bar{\Delta}]^{-,0} +$$
$$[N]^+[\bar{\Delta}]^0 + [\bar{N}]^0[\Delta]^+\}S_2 \equiv [I+I_0]^0[B_2]^0 S_2$$

$$B^+ \rightarrow [I]^-\{[\Delta]^{++}[\bar{\Delta}]^0 + [\Delta]^+[\bar{\Delta}]^+ + [N]^+[\bar{\Delta}]^+ + [\bar{N}]^0[\Delta]^{++}\}S_2$$

$$B^0 \rightarrow [I+I_0]^0[B_1]^0 S_2$$

$$B^0 \rightarrow [I]^-[B_2]^+ S_2 \qquad (3.27)$$

$$B^0 \rightarrow [I]^+\{[N]^0[\bar{N}]^- + [\Delta]^{+,0,-}[\bar{\Delta}]^{--,-,0} +$$
$$[N]^{+,0}[\bar{\Delta}]^{--,-} + [\bar{N}]^{-,0}[\Delta]^{0,-}\}S_2$$

The interference terms between $L_1$ and $L_3$ give

$$B^+ \rightarrow [I]^+[l]^-[\bar{l}]^- S_2 \qquad B^0 \rightarrow [I]^+[l]^-[\bar{\nu}_l]\, S_2$$
$$B^+ \rightarrow [I+I_0]^0[\bar{l}]^+[\nu_l]\, S_2 \qquad B^0 \rightarrow [I+I_0]^0[l]^-[\bar{l}]^+ S_2 \qquad (3.28)$$
$$B^0 \rightarrow [I]^-[\bar{l}]^+[\nu_l]\, S_2$$

And finally we consider the interference terms between $L_2$ and $L_3$. It is easy to see that the decay channels for the present case could be obtained from the first case ( between $L_1$ and $L_2$ ) by the changes $[I]^+ \rightarrow [\bar{l}]^+[\nu_l]$; $[I+I_0]^0 \rightarrow [\bar{l}]^+[l]^-$ and $[\bar{\nu}_l]$ $[\nu_l]$; and $[I]^- \rightarrow [l]^-[\bar{\nu}_l]$.

## IV. DISCUSSIONS ABOUT THE DECAY PROBABILITIES

Into (3.1) we have introduced the coupling constants $G^{j(\lambda)}_{n\alpha}$ which have the dimension $[m]^{1-\alpha-|n-j|}$. Where $\alpha = 0,1$, $j = 0,1,2,3,4$, $n = 0,1,2,3,4$ for the case of $\lambda = \mathcal{K}$; $\alpha = 0,1$, $j = 0$, $n = 0,1,2,3,4$ for the case of $\lambda = S$ and $\alpha = 0,1$, $j = 0,1,2$, $n = 0,1,2,3,4$ for the case of $\lambda = \mathcal{D}$. In the approach wicn is used in this paper the effective coupling constants defining the decay probabilities are the products of the such constants and the polynomials of the masses of the observed particles in the processes. These polynomials arise from the situation that, in the



matrix elements together with the usual momenta the internal momenta $P_i$ are contained. They satisfy the equations $P_i^2 = m_i^2$, where $m_i$ are the masses of the particles in the initial and final states. By L⊗O(4) invariance the such $P_i$ must be presented in the O(4) invariant form $P_i^2$, $P_i P_j$ ... And from these, the scalar products of the $P_i$, $P_j$... depend on the masses and the orientations of these internal momenta. And using the fact that the experiments are made with very large number of particles, the above mentioned scalar products should be taken in everaging on the mass-surfares (on the Euclidian 3-dimensional spheres) [9] and in the results the probability expressions will contain only the usual momenta and masses. Here we would have a notice that the averages on this ways (in Euclidian Space) do not leadto the change of the orders of probabilities.

An other problem for which we must consider is the difference of the dimensions of the coupling constants $G^{j(\lambda)}_{n\alpha}$. For a solution of the problem we take in consideration the quantities $g^{j(\lambda)}_{n\alpha}(p,P) = G^{j(\lambda)}_{n\alpha}\partial_{|n-j|}\partial_\alpha$ which have the dimension [m]. Then the matrix elements should be of form $g(p,P)M^{(\alpha)}$. The structure of the $M^{(\alpha)}$ are depend on the type of the decays.

On the other side, considering the experimental facts we can see that the decays with creation of the particles in a family take the near values of probability : $B^+ \rightarrow K^*(892)\gamma$, $B^+ \rightarrow K_1^+(1400)\gamma$, $B^+ \rightarrow K_1^+(1270)\gamma$, $B^+ \rightarrow K_2^*(1430)^+\gamma$, $B^+ \rightarrow K^*(1680)^+\gamma$, $B^+ \rightarrow K_3^*(1780)^+\gamma$, $B^+ \rightarrow K_4^*(2045)^+\gamma$, ... occuring with the probabilities $< 5.5\times10^{-4}$, $< 6.6\times10^{-3}$, $< 2.0\times10^{-3}$, $< 1.3\times10^{-3}$, $< 1.7\times10^{-3}$, $< 5\times10^{-3}$, $< 9.0\times10^{-3}$... respectively; $B^0 \rightarrow K^*(892)^0\gamma$, $B^0 \rightarrow K_1(1270)^0\gamma$, $B^0 \rightarrow K_1(1400)^0\gamma$, $B^0 \rightarrow K_2^*(1430)^0\gamma$, $K^*(1680)^0\gamma$, $K_3^*(1780)^0\gamma$, $K_4^*(2045)^0\gamma$ etc... occuring with the probabilities $< 2.8\times10^{-4}$, $< 7.8\times10^{-3}$, $< 4.8\times10^{-3}$, $< 4.4\times10^{-3}$, $< 2.2\times10^{-3}$, $< 1.1\times10^{-2}$, $< 4.8\times10^{-3}$ ... respectively . And we can suppose that the $g^{j(\lambda)}_{n\alpha}$ do not depend on j.

Furthermore we have decays : $B^+ \rightarrow K^0\pi^+$, $B^+ \rightarrow K^+\rho^0$, $B^+ \rightarrow K^+\phi$, which take the probabilities $< 9\times10^{-5}$, $< 7\times10^{-5}$, $< 8\times10^{-5}$, respectively ; $B^0 \rightarrow K^+\pi^-$ , $B^0 \rightarrow K^0\rho^0$ , $B^0 \rightarrow K^0\phi$ , $B^0 \rightarrow K^0 f_0(975)$ , $B^0 \rightarrow K^*(892)^+\pi^-$ , $B^0 \rightarrow K^*(892)^0\rho^0$ , $B^0 \rightarrow K^*(892)^0\phi$ , $B^0 \rightarrow K^*(892)^0 f_0(975)$, ... which take the probabilities $< 9\times10^{-5}$,

$< 5.8\times10^{-4}$ , $< 4.9\times10^{-4}$ , $< 4.2\times10^{-4}$ , $< 4.4\times10^{-4}$, $< 6.7\times10^{-4}$, $< 4.4\times10^{-4}$, $< 2.0\times10^{-4}$, ... respectively . So we can suppose that the $g^{j(\lambda)}_{n\alpha}$ could not depend on $j$, $n$, $\alpha$ . And we can write $g^{j(\lambda)}_{n\alpha}(p,P) \equiv g^{\lambda}(p,P)$ ( the internal momenta should be taken in averaging).

Below we shall consider the estimation of the magnitudes of the quantities g and use the such values for the evaluation of the probabilities of different decay types. Of course, the such estimation is very gross and it have only some signification for the ideas of the magnitudes of the last quantities.

Let us consider now the decays with creation of the K-family mesons. These decays relate to the quantities $g^K$. For the $B^+$ in the first approximation we have deduced the decay channels and presented in (3.3). There are about 800 channels. And from the experimenta data we have that the decays of the type $B \rightarrow K$ anything take a probability 148%. So, if we take a symmetry between $B^+$ and $B^-$ (Lagrangian (3.1)) we shall have a probability about 74% for the decays of $B^+$ with creation of the K-mesons: $B^+ \rightarrow K$ anything.

Firstly we suppose that , anything is one particle . Then theoretically we have about 50 channels of the last type and approximately we shall have that each channel take a probability ~ 1% and the $g^K$ for this case should be ~ $10^{-1}$.

Secondly, if "anything" is not a single particle, but it is a system of the particles (two, three ... particles). Then we can have an explanation that the decays of $B^+$ in the first stage are into a very unstable particle of the K-family mesons and a normal meson and this unstable strange mesons, in the second stage should be disintergated into K-meson and the other normal mesons. This explantion is based on the facts that, in the K-family particle group, except the Kaons being relatively stable, the other mesons are unstable: the $K^*(892)$, $K_1(1270)$, $K^*(1370)$, $K_1(1400)$, $K^*_0(1430)$, $K^*_2(1430)$, $K^*(1680)$, $K_2(1770)$, $K^*_3(1780)$ and $K^*_4(2045)$ have the full widths 50 Mev, 90 Mev, 114 Mev, 174 Mev, 287 Mev, 454 Mev, 99 Mev, 136 Mev, 164 Mev and 198 Mev, respectively.



And these unstable mesons will be disintegrated dominantely into $K\pi$ and $K^*(892)\pi$ [13]. After the Kaons, the $K^*(892)$ are the ones having the most large values of mean life ($\Gamma$ = 50 Mev) and these mesons generally are disintegrated into $K\pi$ (~ 100%) [13] ( until now the decays with creation of the $K_j$ ( m > 892) and a normal meson are absent in the data).

So in the above considered hypotheses it can be seen that the $g^k$ should take the values about $\sqrt{10^{-3}}$ .

Now we consider the decay channels in (3.2′). They are deduced in the second approximation, with exchange of the virtual anomalous mesons. Here we must make a notice that, in the such anomalous mesons only the K-family mesons could be exchanged. Really as we have proved above, in III.1.4, there is the particle-antiparticle opposition between the K-family and D-family mesons and by this the exchange of a D-family particle is forbidden - In this exchange the usual causality and the microcausality are violated and since the matrix elements must be equal to zero [20]. And we have only the one particle exchanges of the mesons of K-family. Let us consider the case of creation of the Kaons. There are 11 such mesons and each of the channels of the decays into two normal mesons and a Kaon should take a decay probability around $10^{-2}$- $10^{-4}$. In the data we have one decay of the such type: $K^0\pi^+\pi^-$ which is observed with the probability < $10^{-4}$ . It can be seen that if instead of the Kaons (j=0) in the decay productions will be the $K_1$ , $K_2$ , $K_3$ , $K_4$ , where the indices denote the spins of the anormalous mesons, the number of the exchanges of the virtual anormalous mesons should be one. And the decay probabilities should on 100 times less than the ones of the decays with creation of the Kaons.

Let us consider the decays into two normal mesons, which were presented in (3.4). These decays are deduced in the second approximation. And using the same arguments as we have made for the last case , we can expect that their decay probabilities will be in the interval of $10^{-2}$- $10^{-4}$. In the data we have the decays of this type : $\pi^+\pi^0$ , $\rho^0\pi^+$ , $\pi^+f_0(975)$ , $\pi^+f_2(1270)$ , $\rho^0a_1(1260)$, $\rho^0a_2(1320)$ , $\pi^+\pi^-$, $\pi^{\pm}\rho^{\mp}$ , $\pi^{\pm}a_1(1260)^{\mp}$ , $\pi^{\pm}a_2(1320)^{\mp}$, $\rho^0\rho^0$, and $a_1(1260)^+a_1(1260)^-$ . They occur with the following decay probabilities: $<2.3\times10^{-3}$, $<1.5\times10^{-4}$, $<1.2\times10^{-4}$, $<2.1\times10^{-4}$, $<5.4\times10^{-4}$, $<6.5\times10^{-4}$, $<9\times10^{-5}$, $<6.1\times10^{-3}$, $<5.7\times10^{-4}$, $<3.5\times10^{-4}$, $<3.4\times10^{-4}$ , and $<3.2\times10^{-3}$ respectively.

Now we consider the decays of B into the anormalous mesons

We have deduced in (3.6) the decay $B^+$ and $B^0$ into particles of the K-family mesons (and an unobservable spurion $S_z$). We have the rule $\Delta I_{H3}=\frac{1}{2}$ and $\Delta S_{Ht}=1$ if we don't take into account the $S_z$, where H for a denotation of the hadrons. The decay probabilities of these channels are determined by the constants $g^k$. They occur in the second approximation with exchange of a virtual normal mesons. And using the values of $g$ which were discussed above we shall have that the decay probabilities of this considered case: they are around $10^{-4}$- $10^{-6}$. In the data not any detailed channels of this type is observed yet, however the such decays could be contained in the decays $B^+\rightarrow K$ anything and in the similar ones of $B^0$.

We consider now the decays, presented in (3.7), (3.8) and (3.12). Here we must estimate the magnitudes of the $g^D$ and $g^S$. From the data we have some detailed channels of the decay type (3.12). They are $B^+\rightarrow \bar{D}^0\pi^+$, $B^+\rightarrow \bar{D}^0\rho^+$, $B^+\rightarrow D^*(2010)\pi^+$, $B^0\rightarrow D^-\pi^+$, $B^0\rightarrow D^-\rho^+$, $B^0\rightarrow D^0\rho^0$, $B^0\rightarrow D^*(2010)\ \pi^+$, $B^0\rightarrow D^*(2010)\ \rho^+$ which were observed with the following decay probabilities: $2.9\times10^{-3}$, $2.1\times10^{-2}$, $3\times10^{-3}$, $3.7\times10^{-3}$, $2.2\times10^{-2}$, $<3\times10^{-3}$, $3.3\times10^{-3}$ and $\sim10^{-2}$ respectively. Each of the decay probability of the channels in (3.12) will be determined by $[g^S]^4[g^D]^2$.

The decays of (3.8) are determined by $[g^S]^2[g^D]^2$ and $[g^D]^4$. And from the data we can see that not any detailed decay channel was observed. However there are the decays of the charged B-mesons of the type $B\rightarrow D^{\pm}$anything and $B\rightarrow D^0/\bar{D}^0$anything occuring with the probability 56% . So we can estimate that the decays of the types $B^+\rightarrow D^-$anything and $B^+\rightarrow \bar{D}^0$anything take the probability about 28%.

The decays of the first type $B^+\rightarrow D^-$anything could happen only in the high orders of approximations $n>3$ and so we can take into account only the decay of the second type $B^+\rightarrow \bar{D}^0$anything. The anything here should be $[\mathcal{K}]^+$ in (3.7), $[\mathcal{D}]^+$ in



(3.8) and $[I]^+$ in (3.12) . And if we take $g^D$ about $8\times10^{-1}$ and $g^S$ about $2.0\times10^{-1}$ we can explain the decay probabilities in (3.7), (3.8) and (3.12). Really, as was mentioned, each of the decays of (3.12) should be determined by $[g^S]^4[g^D]^2$ and using the last values of the $g^D$ and $g^S$ we shall have that the decay probabilities for each channels in (3.12) is in order of $10^{-3}$. Here we have chosen the magnitude of the $g^D$ and $g^S$in accordance to the case of creation of a pion.

The decay probabilities in (3.8) are determined by $[g^S]^2[g^D]^2$ and $[g^D]^4$. They take the values about $10^{-2}$. The detailed decays of B into two $\mathcal{D}$-mesons are not observed yet. They could be contained in two decay types which were mentioned above.

Now we consider the case of (3.7). The decay probability of each of the such case is determined by $[g^D]^2[g^K]^2$ and we can see that the last should have a value around $10^{-3}$ and $10^{-4}$. The detailed channels of our present case also are not observed yet . They could be contained in the decays of the types $\bar{\mathcal{D}}$ anything and K anything.

Let us consider the decays with creation of $\mathcal{D}_s$-mesons. The decay channels deduced in the first approximation are presented in (3.10). The decay probabilities of this type are determined by $g^D$. So we can estimate that these probabilities are in magnitude of $10^{-2}$. And from the data we have decay $B\rightarrow D_s^{\pm}$anything occuring with the probability ~1.2%. The such decay type could contain the decays of (3.10).

Analogously we can estimate that the decay in (3.9), (3.11) and (3.13) should be with the probabilities $\sim10^{-6}$-$10^{-7}$,$\sim10^{-4}$-$10^{-5}$, and $\sim10^{-4}$- $10^{-5}$ respectively.

About the decay probabilities of the decays in higher approximations and the decays occuring in two stages we have considered above and let us consider now the decay with creation of the baryons

We consider the case of (3.16). From the data we have some decays of the suche type: $B^+\rightarrow \bar{\Delta}^0 p$, $B^+\rightarrow \bar{\Delta}^{++}\bar{p}$ ; $B^0\rightarrow \bar{p}p$ , $B^+\rightarrow \Delta^0\bar{\Delta}^0$, $B^+\rightarrow \Delta^{++}\Delta^{--}$ etc ... which occur with the probabilities

$< 3.3\times10^{-4}$ , $< 1.3\times10^{-4}$ ; $<4\times10^{-5}$ , $<1.8\times10^{-3}$ , $<1.3\times10^{-4}$ , ... Analogously as for the last Lagrangian we consider here the quantities $g = G^{j}_{nab,\alpha\lambda\delta}\partial_{|n-j|}\partial_{\alpha}$ with a supposition that they do not depend on the index j, a, b, $\lambda$, $\delta$. Then we can estimate for the magnitude of the g: $g \sim 10^{-2}$.

The decays in (3.17), (3.18) and (3.19) should depend on the product of g and $a_s$ . Not any of the such decay type was observed . And so we can suppose that the $a_s$ must have the values < 1.

From the data we can see some channles of the other types $B^+\to p\bar{p}\pi^+$, $B^+\to p\bar{p}\pi^+\pi^+\pi^-$, $B^0\to p\bar{p}\pi^+\pi^-$ which occur with the probabilities $<1.4\times10^{-4}$ , $<4,7\times10^{-4}$ ; $<6\times10^{-4}$ respectively and $B^+\to p\bar{\Lambda}\pi^+\pi^-$, $B^+\to p\bar{\Lambda}\pi^-$, ... with the probabilities $<1.8\times10^{-4}$, $<2.\times10^{-4}$ ... And a rational explanation for these is : they occur in the two-stage decays.

Now we consider the decay of B-meson into leptons and hadrons. The deduced channels are presented in the (3.24), (3.25) and (3.26) .

From the data we have the following observed decays: $B \to e^{\pm}\nu_e$ hadrons , $B \to \mu^{\pm}\nu_{\mu}$ hadrons , ( B is a charged particle ) $B^+\to K^+\mu^+\mu^-$, $B^+\to K^+e^+e^-$; $B^0\to D^-l^+\nu$, $B^0\to D^*(2010)l^+\nu$, $B^0\to K^0\mu^+\mu^-$, $B^0\to K^0e^+e^-$, $B^0\to \mu^+\mu^-$, and $B^0\to e^+e^-$with the probabilities: 12%, 11%, $<1.5\times10^{-4}$, $<5\times10^{-5}$, 1.8%, 9.8%, $<4.5\times10^{-4}$, $<6.5\times10^{-4}$, $<5\times10^{-5}$ and $<3\times10^{-5}$, respectively.

If we introduce , as for the last cases , the quantities $g'^{\lambda}(p,P) = G^{\lambda}_{i}\partial_{|j-i|}$ of the dimension $[m]^0$ , we can have the following estimation for their magnitude.

In (3.24), and (3.26) which were deduced in the first approximation, the hadrons are of the K-family and D-family particles. Let us consider (3.24). It can be seen that the coupling quantities for the first and third channel types will be $g'^{K}$ and then we have that they take the values about $2\times\sqrt{10^{-3}}$ . The decays of the second and fourth types are determined by $g'^{K}\varkappa_{l}$ . Using the above mentioned data of $B^0\to K^0\mu^+\mu^-$, $B^0\to K^0e^+e^-$ we



can have $\varkappa_l \approx 10^{-1}$. Analogously for (3.25) we have $g'^{S} = \sqrt{10^{-3}}$.

The decays of the type (3.26) are determined by $(g'^{D}g'^{S})^2$. Here there are 6 Feynman's diagrams with the exchange of the virtual $\nu_e$, $\nu_{\mu}$and $\nu_{\tau}$ . So we shall have $6\,(g'^{D}g'^{S})^2 \sim 10^{-2}$ and from which we have $g'^{D} \sim 5.10^{-1}$.

It could be seen that using above mentioned quantities for the cases of the interference terms of the Lagrangians $L_1$, $L_2$, and $L_3$ , as well as for the case of two-stage decays we shall have reasonable values for the decay probabilities [13].

Finally we would like to emphazise a fact that the form of the Lagrangian $L_1$, $L_2$, $L_3$ with the sum over the spins and isospins is reasonable for explanation of the decay probabilities - A probability of the detailed channels takes the values on $10^{-2}$- $10^{-3}$ times less than the probability of the decay type containing these channels.

## V. CONCLUSION

We have deduced the decay channels of the B-mesons in using the Lagrangians which are formed on L⊗O(4) invariance the principle of minimal structure.

All decay channels observed in the experiments until now are present in the theoretically deduced ones. The different possible interaction types were considered and so we hope that the new observed channels will be also contained in the channels predicted from (3.1), (3.15) and (3.22).*

---

* According to [21], for the decays of $B^+$ there are 52 new exclusivee channels (in [13] are present 35 channels which were discussed above). These new channels just are predicted in (3.2), (3.3), (3.4), (3.6), (3.10), (3.24), (3.26) and in the interference terms of (3.1) and (3.22) of (3.1) and (3.24) and of (3.15) and (3.22).

For the decays of $B^0$, there are 38 new exclusive channels [21] (in [13], 44 channels) and they are predicted in (3.2) (3.3), (3.4), (3.6), (3.9), (3.10), (3.13), (3.18), (3.28)and in the interference terms of (3.1) and (3.22) and of (3.1) and (3.24).

The estimation of the probability magnitudes was made, however the results in this preliminary consideration could be only very gross. The such situation relates to the fact that in th. probability expressions the internal momenta are contained. These momenta could not be directly observed, but by L⊗O(4) invariance they are presented in the O(4) invariance. And by the very large number of the particles in the experiments, the probability expessions should be taken in averaging on the mass-surfaces. Then the quantitieswhich define the probability values will be the products of the coupling constants in the Lagrangians and the polynomials of the masses [9]. Just these quantities could be used for comparison to the experimantal data.

Related to this situation we can have a result that, for the decays of the particles we have not the fixed coupling constants as in the case of elastic electromagnetic interaction but we have the quantities being the polynomials of the masses.

An argument for the above mentioned deduction is that, in the Quantum electronagnetic interaction the constant e, a quantity which is observed, plays the role of a coupling constant. While, in the decays of the particles the such similar quantities are not presented.



ACKNOWLEDGMENTS

One of the authors (D. V. P.) deeply thanks Professor Abdus Salam, the International Atomic Energy Agency and UNESCO for hospitality at the ICTP, Trieste, Italy. He also deeply thanks the Nishina Memorial Foundation of Japan for the financial support of the visit in Japan in 1992.

The authors express gratitude to Professor J. Strathdee in the International Centre for Theoretical Physics, Professor H. Miyazawa in the Kanagawa University, Professors K. Igi and H. Terezawa in the University of Tokyo, Professors K. Higashijimaand T. Yukawa in the National Laboratory of High Energy Physics, KEK, and Professor T. Inami in to Kyoto University, for the discussions of the problems in this paper.

This work is performed with financial support of the National Program for Fundamental Research of STE Ministry of Vietnam.

## REFERENCES


1. John F. Donoghue and Eugene Golowich, B-meson decays and the Weinberg Higgs-boson. Phys. Rev. D, V.37 N° 9. p.2543 (1988).
2. J. H. Kühn, S. Nussinov annd R. Ruckl, Charmonium Production in B-decays, Z, Physik C, Particles and Fields 5, p. 117 (1980)
3. P. H. Cox, S. Hovater, and S. T. Jones, QCD corrections to the decay $B \to \Psi X$, Phys. Rev. D, V32, N° 5, p. 1157 (1985).
4. G. Altarelli, et. al., Leptonic decay of Heavy Flavors, Nuclear Physics B208, P.365, (1982).
5. M. Wilbel, B. Stech, and M. Bauer, Exclusive Semileptonic Decays of Heavy Mesons, Z. Phys. C - Particles and Fields, 29 , P.637 (1985).
6. L. Angelini, et. al., A Reavistic Model of the Semileptonic Decays of Beauty, Phys. lett. B, V 172, N°3, 4, p.477 (1986)
7. Nathan Isgur and Daryl Scora, Semileptonic B and D decays in the quark model, Phys. Rev. D, V.39 N°3, p.799, (1989).
8. M. Jarfi and O. Lazrak, Pole model of B-meson decays into baryon-antibaryon pairs.
9. Duong van Phi, Tran Tat Dat et al. Decays of the Hyperons, IC/90/127 International Centre for Theoretical Physics, 1990, Trieste, Italy.
10. Duong Van Phi and Duong Anh Duc, Allowed decay channels of $\mu$-leptons and $\tau$-leptons. Annals of Hochiminh City University 1, 1992 Duong Van Phiand Duong Anh Duc, Allowed decay channels of normal mesons. Annals of Hochiminh City University 2, 1992
11. Duong Van Phi and Duong Anh Duc, Decay of $J/\Psi$, IC/91/227 . International Centre for Theoretical Physics, 1991,Trieste, Italy, (will be published in NUOVO CIMENTO A ).
    Duong Van Phi and Duong Anh Duc, Decay of D-mesons (Send to publication in NUOVO CIMENTO A ).
12. Duong Van Phi, About a complex Space and the Theory of Elementary Particles Izvestia Vuzov, Phys. 1964, 6, 71





13. "Review of particle properties", Phys. Lett. B239, April 1990.
14. V. Heisenberg , Introduction to the Unified Field Theory of Elementary particles, London, Newyork, Sydney, 1966
15. Duong Van Phi, Spurions and the decays of K-Mesons. Bul. of HochiMinh City University. 1987. 6, 25.
16. Duong Van Phi. Field Theory in Unified Space and the Spectral Representation. Bul. of Hochiminh City University, 1987, 6,46
17. Duong Van Phi and Duong Anh Duc, An Aproach to the Quantum Field Theory in an 8-dimensional Unified Space, KEK-TH 348,KEK Preprint 92-95, September 1992.
18. Duong Van Phi, Symmetry in Unified Space. Bul. of Hochiminh City University, 1986, 5, 123
19. V.B. Berestexky. E.M. Liftshitx, L.P. Pitaevsky. Relativistic Quantum Theory, Part I, Sciences Moscow, 1968.
20. Duong Van Phi , Approach of Quantum Field Theory in Unified Space and the Problem of Microcausality, Bul. of Hochiminh University, 1990, 7, 75
21. Review of Particle Properties, Phys. Rev. D, V.45 June, 1992