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Kh.M.Beshtoev

DYNAMICAL ANALOGY OF THE KOBAYASHI-MASKAWA MATRIX (CP-VIOLATION) AND AN ESTIMATION OF THE CREATION CROSS SECTION AND DECAY WIDTHS OF THE VECTOR BOSONS ARISEN IN THIS CASE

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1.INTRODUCTION

The theory of electroweak interactions,at the present time, has the status of a theory which is confirmed with a high degree of precision. However, some experimental results (the existence of quarks and of leptons families,etc.) did not get any explanation in the framework of the theory. One such part of the electroweak theory is the existence of quark mixing which is introduced by the Cabibbo-Kobayashi-Maskawa matrices (i.e., these matrices are used for parametrization of the quark mixing).

In previous work [1] a dynamical mechanism of quark mixing by the use of three doublets of massive vector carriers of weak interaction $B^{\pm},C^{\pm},D^{\pm}$ was suggested.

In this work in continuation of [1] a dynamical mechanism of quark mixing including CP-violation by using four doublets of massive vector carriers of weak interaction $B^{\pm},C^{\pm},D^{\pm}$ $E^{\pm}$ is suggested, i.e., expansion of the electroweak theory on a tree level is proposed, where together with the $W^{\pm},Z^{0}$ bosons there arise four doublets of massive vector carriers of the weak interaction $B^{\pm},C^{\pm},D^{\pm},E^{\pm}$ leading to the quark mixing. An estimation of the boson masses and the quasielastic reactions proceeding through these bosons and the creation cross section and also decay widths of B boson are given.

11. DYNAMICAL ANALOGY OF THE KOBAYASHI-MASKAWA MATRIX

Now let us go on to generalization of the work [1] which includes CP-violation.

In the case of three families of quarks the current J^{μ} has next form:

$$J^{\mu} = | \bar{u} \ \bar{c} \ \bar{t} |_L \gamma^{\mu} V \begin{vmatrix} d \\ s \\ b \end{vmatrix}_L \qquad (1)$$

$$V = \begin{vmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{vmatrix} ,$$

where V is Kobayashi-Maskawa matrix [2].

We shall choose a parametrization of the matrix V in the form suggested by Maiani [3]

$$V = \begin{vmatrix} 1 & 0 & 0 \\ 0 & c_\gamma & s_\gamma \\ 0 & -s_\gamma & c_\gamma \end{vmatrix} \begin{vmatrix} c_\beta & 0 & s_\beta e^{-i\delta} \\ 0 & 1 & 0 \\ -s_\beta e^{i\delta} & 0 & c_\beta \end{vmatrix} \begin{vmatrix} c_\theta & s_\theta & 0 \\ -s_\theta & c_\theta & 0 \\ 0 & 0 & 1 \end{vmatrix} , \qquad (2)$$

$$c_\theta = \cos\theta , \quad s_\theta = \sin\theta, \quad e^{i\delta} = \cos\delta + i\sin\delta$$

To the nondiagonal terms (which are responsible for mixing of the d,s,b- quarks and CP-violation in the three matrices) in (2) we shall make correspond four doublets of vector bosons $B^{\pm}, C^{\pm}, D^{\pm}, E^{\pm}$ (we will suppose that the real part of $\mathrm{Re}(s_\beta e^{i\delta}) = s_\beta \cos\delta$ corresponds to the vector boson $C^{\pm}$, and the imaginary part of $\mathrm{Im}(s_\beta e^{i\delta}) = s_\beta \sin\delta$ corresponds to the vector boson $E^{\pm}$ (the couple constant of E is an imaginary value !)) whose contributions are parametrized by four angles $\theta, \beta, \gamma, \delta$. Then , when $q^2 \ll m_W^2$, we get:

$$\mathrm{tg}\,\theta \cong \frac{m_W^2 \, G_B}{m_B^2 \, G_W} , \qquad \mathrm{tg}\,\beta \cong \frac{m_W^2 \, G_C}{m_C^2 \, G_W}$$

$$\mathrm{tg}\,\gamma \cong \frac{m_W^2 \, G_D}{m_D^2 \, G_W} . \qquad \mathrm{tg}\,\delta \cong \frac{m_W^2 \, G_E}{m_E^2 \, G_W} \qquad (3)$$

If $G_{B^{\pm}} \cong G_{C^{\pm}} \cong G_{D^{\pm}} \cong G_{E^{\pm}} \cong G_{W^{\pm}}$, then

$$\mathrm{tg}\,\theta \cong \frac{m_W^2}{m_B^2} , \qquad \mathrm{tg}\,\beta \cong \frac{m_W^2}{m_C^2}$$

$$\mathrm{tg}\,\gamma \cong \frac{m_W^2}{m_D^2} . \qquad \mathrm{tg}\,\delta \cong \frac{m_W^2}{m_E^2} \qquad (4)$$

Concerning the neutral vector bosons B^0 , C^0 , D^0, E^0, the neutral scalar bosons B'^0, C'^0, D'^0, E'^0 and the GIM mechanism [4] we can repeat the same arguments which were given in the previous work [1].

111 . REACTIONS PROCEEDING THROUGH THE $B^{\pm}, C^{\pm}, D^{\pm}$ BOSONS AND ESTIMATION OF THEIR MASSES

The reactions with substitution $d \longleftrightarrow s$, $d \longleftrightarrow b$, $s \longleftrightarrow b$ proceed via the $B^{\pm}, C^{\pm}, D^{\pm}, E^{\pm}$ bosons. Besides the decays of leptons and hadrons, the following quasi-elastic reactions proceed through exchange of the bosons:

a) $u + d \xrightarrow{B} u + s$, $p + p \longrightarrow p + \Sigma^+$,

$u(\bar{u}) + \bar{s}(s) \xrightarrow{B} \nu_i(\bar{\nu}_i) + \bar{e}_i(e_i)$, $i = e,\mu,\tau$

$\nu_i(\bar{\nu}_i) + \bar{e}_i(e_i) \xrightarrow{B} u(\bar{u}) + \bar{s}(s)$;

b) $u + d \xrightarrow{C} u + b$, $p + p \longrightarrow p + \Sigma^+(q_b)$, (5)

$u(\bar{u}) + \bar{b}(b) \xrightarrow{C} \nu_i(\bar{\nu}_i) + \bar{e}_i(e_i)$,

$\nu_i(\bar{\nu}_i) + \bar{e}_i(e_i) \xrightarrow{C} u(\bar{u}) + \bar{b}(b)$;

c) $c + s \xrightarrow{D} c + b$,

$c(\bar{c}) + \bar{b}(b) \xrightarrow{D} \nu_i(\bar{\nu}_i) + \bar{e}_i(e_i)$

$\nu_i(\bar{\nu}_i) + \bar{e}_i(e_i) \xrightarrow{D} c(\bar{c}) + \bar{b}(b)$,

d) Through E boson will go the next reactions with CP-violation $K_1^o \longleftrightarrow K_2^o$, $B_1^o \longleftrightarrow B_2^o$ ... et cetera.

Let us estimate the masses of the $B^{\pm},C^{\pm},D^{\pm},E^{\pm}$ bosons. For this purpose we shall use the data from [5] and equation (4)

1) $tg\ \theta \cong 0.218 \div 0.224$,

$m_{B^{\pm}} \cong 169.5 \div 171.8$ GeV ;

2) $tg\ \beta \cong 0.032 \div 0.054$, (6)

$m_{C^{\pm}} \cong 345.2 \div 448.4$ GeV ;

3) $tg\ \gamma \cong 0.002 \div 0.007$,

$m_{D^{\pm}} \cong 958.8 \div 1794$ GeV .

4) $tg\ \delta \cong 0.00036 \div 0.00037$,

$m_{E^{\pm}} \cong 4170 \div 4230$ GeV.

IV. AN ESTIMATION OF THE CREATION CROSS SECTION AND DECAY WIDTHS OF THE VECTOR BOSONS

For estimation of the creation cross sections of the vector bosons $B^{\pm},C^{\pm},D^{\pm},E^{\pm}$ at resonance in $p\bar{p}$ reaction we can use standard formula [6] ($g_W = g_X$):

$$\sigma_X = \frac{4\pi^2}{3} \left(\frac{\Gamma_X}{m_X} \right) Br(X \longrightarrow q\bar{q})\ Br(X \longrightarrow f) \tag{7}$$

$$\int \int dx_1\, dx_2\, u_i(x_1)\, \bar{u}_k(x_2)\, \delta(x_1 x_2 - M_X^2 / s) ,$$

where $s = (p_p + p_{\bar{p}})^2$, Br(...) is branching mode probability, $u_i(x)$ are quark structure functions, i = u, d, s quarks, m_X is mass of the X vector boson, X = B,C,D,E is boson, Γ_X is total width of the X vector boson.

Using expression (7) at energy E = 1.8 TeV (FNAL) we obtain the next values for creating cross sections of $B^{\pm}$ boson at resonance:

a) $\sigma(u\,\bar{d} \xrightarrow{B} all) \cong 245$ pb, (8)

$\sigma(u\,\bar{d} \xrightarrow{B} e\,\bar{\nu}) \cong 20$ pb ,

in this case we used quark structure functions of u, d quarks from [7].

b) $\sigma(u \bar{s} \xrightarrow{B} all) \cong 7.6$ pb, (9)
$\sigma(u \bar{s} \xrightarrow{B} e \bar{\nu}) \cong 0.64$ pb ,

in this case we used u, s quark structure function from [8].

Using standard expression for width $\Gamma(\ldots)$

$$\Gamma(B \longrightarrow e\bar{\nu},\nu\bar{e}) = \frac{g_B^2 m_B}{48\pi} , \quad (10)$$

we obtain the next values for $\Gamma(B\ldots)$, when $g_B \cong g_W$

$$\Gamma(B \longrightarrow e\bar{\nu},\nu\bar{e}) \cong 0.48 \text{ GeV} ,$$

$$\Gamma(B \longrightarrow \text{leptons}) \cong 3\,\Gamma(B \longrightarrow e\bar{\nu},\nu\bar{e}) \cong 1.44 \text{ GeV} , \quad (11)$$

$$\Gamma(B \longrightarrow u\bar{s}) \cong 3\Gamma(B \longrightarrow e\bar{\nu}),$$

if $\Gamma(B \longrightarrow u\bar{s}) \cong \Gamma(B \longrightarrow u\bar{d})$ then,

$$\Gamma_{tot} \cong 4.30 \text{GeV}. \quad (12)$$

V. CONCLUSION

A dynamical analogy of the Kobayashi-Maskawa matrix (inclding CP-violation), i.e. a phenomenological expansion of the weak interaction theory working on a tree level is proposed. For this purpose four doublets of vector bosons $B^{\pm}, C^{\pm}, D^{\pm}, E^{\pm}$ are introduced. Estimation of their masses ($m_B \cong 170$ GeV. , $m_C \cong 345$ GeV., $m_D \cong 1000$ GeV. , $m_E \cong 4200$ GeV.) is performed. The quasielastic reactions proceeding through the exchange of these bosons are listed. The estimation of the creation cross section for energy E = 1.8 TeV.(FNAL) and decay widths of B boson is given.

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