Acta Physica Academiae Scientiarum Hungaricae, Tomus 27, pp. 549—558 (1969)

TWO-TRIPLET MODEL OF "DIRECT" MUON PRODUCTION*

By

K. LADÁNYI

RESEARCH GROUP FOR THEORETICAL PHYSICS OF THE HUNGARIAN ACADEMY OF SCIENCES, BUDAPEST

(Received 18. III. 1969)

A particular two-triplet model of "direct" lepton productions is suggested by assuming that both leptons and hadrons belong to representations of the six-dimensional rotation group SO_6.

I. Introduction

Considerable interest has recently been attached to the deep-mine experiment of BERGESON et al. [1, 2] which indicates a failure of the secΘ law in the energy domain 10^3—10^4 GeV. This implies either direct production of cosmic-ray muons of $\gtrsim 10^3$ GeV or production via a very short-lived parent. Similar production of high-energy electrons has also been proposed [2] in order to explain some mu-less shower data. On the other hand, the Brookhaven experiment [3] verified the secΘ law below 300 GeV. In addition, the data re-examined by NASH and WOLFENDALE [4] imply no evidence for direct muon production in the energy domain 500—1000 GeV. The reported experiments indicate, if all the data are correct, the absence of a transition region between pure pion and kaon parentage below 10^3 GeV and "direct" lepton production above this energy. To explain this situation BJORKEN et al. [5] suggested some theoretical models involving the strong production of a massive particle X which is stable under strong and electromagnetic interactions and decays with high probability into a state containing a muon. According to the most popular assumptions the X particle could be an intermediate boson, produced strongly in pairs, along the lines suggested by OKUBO, MARSHAK and coworkers [6]. The experiment of BERGESON et al. seems to indicate, however, that the vertical muon intensity arises entirely from "direct" production and that the conventional flux of pions and kaons has effectively vanished [7].

As a second theoretical possibility one may conjecture that the X particles are strongly interacting heavy triplets with integral charge [5, 8—11]. This interpretation is favoured by a recent underground experiment of DARDO, PENENGO and SITTE [12]. Two distinct kinds of strongly interacting particles

* Dedicated to Prof. P. GOMBÁS on his 60th birthday.

have been observed. The first group has all the characteristics of pions, the second appears only with short delays after the triggering muons. To explain the data DARDO at al. suggested that the delayed events are due to particles of a mass about 10 $\sim$ 15 GeV, possibly heavy triplet particles of unit charge. The apparent discrepancy between these conclusions and those of earlier experiments [13] may be explained by the differences in the triggering conditions, if the following assumptions are satisfied. (a) The heavy triplet particles are created in processes involving dissociation of the colliding primaries. (b) The unstable members of the triplets have a dominant decay mode leading directly, without intermediate strongly interacting particles, to energetic muons. This production mechanism seems to be compatible with the results of BERGESON et al. On the other hand, the reported "direct" production of leptons does not follow directly, without additional assumptions, from "conventional" triplet models with integer charge. Although confirmation of the effect and further experimental details are needed, the theoretical study of the problem may lead to useful points of view. In this paper a particular two-triplet model of direct lepton production will be proposed by assuming that both leptons and hadrons belong to representations of the rotation group SO_6.

II. Two-triplet model of leptons. "Direct" production

An interesting two-triplet model of hadrons has been proposed by BACRY, NUYTS and VAN HOVE [9, 10]. In this scheme the hadrons are assigned into representations of the symplectic group Sp_6. In two previous papers [14, 15] we have discussed some general dynamical and symmetry properties of the two-triplet model by assuming that hadrons belong to representations of the six-dimensional rotation group SO_6. The basic representation 6 of the rank-three group SO_6 contains two SU_3 triplets with integer charge. The members of the triplets are the trions denoted by

$$t_1 = T^+,\ t_2 = T^0,\ t_3 = T'^0,\ t_4 = \Theta^0,\ t_5 = \Theta^+,\ t_6 = \Theta'^+. \tag{1}$$

The trions are characterized by spin 1/2 and internal quantum numbers Z, Q, Y, I, I_3, where Z is a new quantum number, related to the supercharge [9]. (Q, Y, I and I_3 denote the electric charge, the hypercharge, the isospin assignment and the third component of isospin, respectively). In addition, the fermion number N of trions is fixed by $N = 1$. These quantum numbers are identical with those of trions belonging to the basic representation 6 of Sp_6 [9]. The state assignments of trions are summarized in Table I. We shall assume that the trions t_m are created by the six-component trion field $\mathbf{t}_m$. Within the framewok of the SO_6 model the known baryons may be regarded

Table I

Quantum numbers of trions

	I_3	I	Y	Z	Q	N
T^+	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{3}$	1	1
T^0	$-\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{3}$	0	1
T'^0	0	0	$-\frac{2}{3}$	$\frac{1}{3}$	0	1
Θ^0	$-\frac{1}{2}$	$\frac{1}{2}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0	1
Θ^+	$\frac{1}{2}$	$\frac{1}{2}$	$-\frac{1}{3}$	$-\frac{1}{3}$	1	1
Θ'^+	0	0	$\frac{2}{3}$	$-\frac{1}{3}$	1	1

as $TT\bar{\Theta}$ systems with $Z = 1$, $N = 1$. In addition, the known mesons are supposed to be $t\bar{t}$ states of $Z = 0$, $N = 0$.

The classification of leptons into the SO_6 scheme is provided by the new quantum number Z. We now put the positron e^+ and the positron-neutrino $\bar{\nu}_e$ into the basic representation 6 of SO_6 by assuming that they are created by "elementary" fields. Thus, e^+ and $\bar{\nu}_e$ are supposed to have the assignments $|Z| = 1/3$ and $N = 1$. If this is so, we have to require exact Z conservation in order to guarantee the conservation of baryons with $Z = 1$ and $N = 1$. In addition, only the approximate hypercharge conservation may lead to an apparent conservation of muon number within the framework of this model. Before considering this problem we shall discuss the e^+, $\bar{\nu}_e$ doublet. Let us call the known leptons $e^\pm$, $\bar{\nu}_e$, ν_e and μ^+, ν_μ, $\bar{\nu}_\mu$ normal fermions of $|Z| = 1/3$, $|N| = 1$. The other particles with $Z \neq N$ will be called exotic particles. We now fix the quantum number Z of e^+ and $\bar{\nu}_e$ by assuming that all the exotic fermions and bosons are unstable particles with a mass $\gtrsim 5$ GeV. By this assumption one obtains $Z = +1/3$ for e^+ and $\bar{\nu}_e$, which can be easily seen as follows. Due to the assignments $Z = 1/3$ and $N = 1$ of e^+ and $\bar{\nu}_e$, the exotic fermions of $Z = 1/3$, $N = 1$ are unstable e g. by hypercharge violating processes. In addition, the exotic fermions with $Z = -1/3$, $N = 1$ (e.g. the trions Θ^0, Θ^+, Θ'^+) may have a Z-conserving decay mode of the type

$$\Theta \to \bar{B} + L + L', \tag{2}$$

where $\bar{B}$ is an antibaryon, represented by a $\Theta\bar{T}\bar{T}$ system with $Z = -1$, $N = -1$, and the particles L and L' may be identified with leptons of $Z = 1/3$, $N = 1$

(e.g. e^+ or $\bar{\nu}_e$). On the other hand, the assignments $Z = -1/3$, $N = 1$ of e^+ and $\bar{\nu}_e$ are excluded by our assumptions, because one of the exotic particles (e.g. a trion T of $Z = 1/3$, $N = 1$) would be absolutely stable in this case.

Summarizing, the members of the T-triplet and the leptons e^+ and $\bar{\nu}_e$ have the common quantum numbers $Z = 1/3$, $N = 1$ in our scheme. However, the constituents T of hadrons are supposed to be collective excitations generated by a self-consistent *nonperturbative* mechanism of strong interactions [15]. The effective masses and couplings of these states may be quite different from those of free leptons. The strong interaction between hadron constituents may be connected with the large "bare" coupling constants obtained in previous dynamical calculations [15]. These "bare" coupling constants are defined by integrals of the spectral functions appearing in the effective interaction kernel. Electrons and neutrinos have no strong couplings to a known boson. Thus, in this model, their large "bare" coupling constants must arise from contributions of the continuous spectrum at very high energies.

The SO_6 properties of leptons will be fixed according to the Cabibbo universality of leptonic and semileptonic weak processes. As a first step we shall construct the weak hadronic current in terms of the six-component trion field $\mathbf{t}$ by generalizing the corresponding expressions of the quark model. In order to ensure universality, one has to assign the weak trion current to the regular representation 15 of SO_6. Compared with the weak quark current, the explicit form of the weak trion current is less trivial because the SO_6 hadrons contain two fermions T and the antifermion $\bar{\Theta}$ simultaneously. For example, let us consider the SO_6 structure of the nucleon doublet* p, n given by [16, 17] (spinor indices are omitted)

$$\mathbf{p} \sim \frac{1}{\sqrt{3}} [\overline{\Theta^0} (\mathbf{T}^0 \mathbf{T}^+ - \mathbf{T}^+ \mathbf{T}^0)], \tag{3}$$

$$\mathbf{n} \sim \frac{1}{\sqrt{3}} [\overline{\Theta^+} (\mathbf{T}^0 \mathbf{T}^+ - \mathbf{T}^+ \mathbf{T}^0)]. \tag{4}$$

It follows that the nuclear β decay is due to a weak decay of the anti-Θ ($\bar{\Theta}$) constituents of nucleons in this model. Consequently, the weak trion current, belonging to the regular representation 15 of SO_6, must have the $V + A$ form according to the $V - A$ coupling observed in semileptonic weak processes of

* The familiar SU_6 results for the baryon magnetic moments may be recovered by assuming that the magnetic moments $\mathbf{M}^{(tH)}$ of the trion constituents of hadrons transform like $\mathbf{M}^{(tH)} \sim \sim \mathbf{I}_3 + (1/2)\,\mathbf{Y}$. In this case the SO_6 transformation properties of $\mathbf{M}^{(tH)}$ are different from those of the electric charge $\mathbf{Q}$.

nucleons. We now can construct the weak Cabibbo current J^μ of trions in a straightforward way. One obtains

$$J^\mu = \bar{\mathbf{t}}\gamma^\mu(1+\gamma_5)\, V^{(+|15)}(\Theta_c)\mathbf{t}\,, \tag{5}$$

$$V^{(\pm|15)}(\Theta_c) = \frac{\bar{\lambda}^{1(15)} \pm i\bar{\lambda}^{2(15)}}{2}\cos\Theta_c + \frac{\bar{\lambda}^{4(15)} \pm i\bar{\lambda}^{5(15)}}{2}\sin\Theta_c\,, \tag{6}$$

where $\gamma_5 = i\gamma^5 = i\gamma^0\gamma^1\gamma^2\gamma^3$, Θ_c is the Cabibbo angle and the matrices $\bar{\lambda}^{j(15)}$ are generators of the group SO_6. [15] contains the complete list of the matrices $\bar{\lambda}^{j(15)}$. The weak current (5) may be written as

$$\mathbf{J}^\mu = \bar{\boldsymbol{l}}\gamma^\mu(1+\gamma_5)\, V^{(+|15)}(0)\boldsymbol{l}\,, \tag{7}$$

where

$$V^{(\pm|15)}(0) = (1/2)\,(\bar{\lambda}^{1(15)} \pm i\bar{\lambda}^{2(15)})$$

and

$$\boldsymbol{l} = U(\Theta_c)\mathbf{t}\,, \tag{8}$$

$$U(\Theta_c) = \exp\,[i\Theta_c\bar{\lambda}^{7(15)}] = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & \cos\Theta_c & \sin\Theta_c & 0 & 0 & 0 \\ 0 & -\sin\Theta_c & \cos\Theta_c & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \cos\Theta_c & \sin\Theta_c \\ 0 & 0 & 0 & 0 & -\sin\Theta_c & \cos\Theta_c \end{pmatrix}. \tag{9}$$

The unitary transformation (8) defines a weak SO_6 space and, in particular, the weak hypercharge Y' and the weak isospin I' in a straightforward way. By this definition the weak quantum numbers Y', I' and I_3' of l_m are identical with the corresponding (strong) SO_6 quantum numbers Y, I and I_3 of t_m ($m = 1, \ldots 6$). In addition, l_n and t_m have a common quantum number Z.

The simplest weak isodoublets of $Z = +1/3$ are given by

$$\boldsymbol{l}_1 \sim \mathbf{T}^+\,, \tag{10}$$

$$\boldsymbol{l}_2 \sim \mathbf{T}^0\cos\Theta_c + \mathbf{T}'^0\sin\Theta_c\,, \tag{11}$$

and the "Ξ-type" members of a (weak) SU_3 15-plet

$$\mathbf{M}^0 \sim [\boldsymbol{l}_3\,\boldsymbol{l}_3\,\bar{\boldsymbol{l}}_2], \tag{12}$$

$$\mathbf{M}^- \sim [\boldsymbol{l}_3\,\boldsymbol{l}_3\,\bar{\boldsymbol{l}}_1] \tag{13}$$

with $\boldsymbol{l}_3 = -\mathbf{T}^0\sin\Theta_c + \mathbf{T}'^0\cos\Theta_c$. Table II contains the relevant quantum numbers of the particles l_1, l_2 M^0 and M^- created by the operators $\boldsymbol{l}_1$, $\boldsymbol{l}_2$, $\mathbf{M}^0$ and $\mathbf{M}^-$, respectively. It should be noted that the structures (12)—(13) imply an SO_6 representation mixing due to the T—Θ effective-mass difference.

Table II

The quantum numbers of l_1, l_2, M^0 and M^-

	I_3'	I'	Y'	Z	Q	N
l_1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{3}$	1	1
l_2	$-\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{3}$	0	1
M^0	$\frac{1}{2}$	$\frac{1}{2}$	$-\frac{5}{3}$	$\frac{1}{3}$	0	1
M^-	$-\frac{1}{2}$	$\frac{1}{2}$	$-\frac{5}{3}$	$\frac{1}{3}$	-1	1

If both leptons and hadrons belong to representations of SO_6, then the sum of leptonic and hadronic weak currents may be reduced to the single trion current (5). The choice of leptonic state assignments is restricted by the following empirical facts. (a) Baryon and lepton conservation. (b) Electron—muon symmetry and the apparent conservation of muon number. (c) V—A structure of leptonic interactions in the conventional form. (d) Cabibbo reduction of the weak coupling strength in semileptonic weak processes. We observe that these conditions are satisfied if the leptons are identified by

$$e^+ = l_1,\ \bar{\nu}_e = l_2,\ \nu_\mu = M^0,\ \mu^- = M^- \tag{14}$$

with (10)—(13) (ν_μ and μ^- denote the muon-neutrino and the muon, respectively, which are assumed to be tightly bound states). In this way baryon and lepton conservations are due to the exact conservation of Z and N. The particles $e^+, \bar{\nu}_e$ and ν_μ, μ^- form two distinct isodoublets in the weak SO_6 space and the apparent conservation of muon number is connected with the (approximate) conservation of the weak hypercharge Y'. We may write the leptonic piece of the weak current (5) in terms of the doublets ν_e, e^- and ν_μ, μ^-. In this conventional form we recover the well known V—A structure which follows from the SO_6 properties (10)—(14) of leptons.

A unified two-triplet model of leptons and hadrons has already been proposed by KLEIN [18]. In his model a single four-component neutrino ν, e^- and μ^- are identified with the antitrions $\bar{\Theta}^0$, $\overline{\Theta^+}$ and $\overline{\Theta'^+}$, respectively. Other triplet models for leptons have also been discussed in the literature, some papers are listed in [19].

Motivated by the structure of leptonic and semileptonic weak interactions, we now suggest that the symmetry properties of leptonic states are fixed by relations (10)—(14). In addition, our model may lead to direct lepton production by a dissociation of colliding hadrons. This process occurs only at very high energies, if the lowest Θ mass is sufficiently large. On the other hand, no absolutely stable exotic particles are to be expected according to the present experimental situation. The simplest Z-conserving dissociation process of two colliding baryons B and B' may be written in the schematic form

$$B + B' = (TT\bar{\Theta}) + (TT\bar{\Theta})' \to L_A + L_B + \bar{\Theta} + L'_A + L'_B + \bar{\Theta}' + \text{photons}, \quad (15)$$

where the common notation L is used for the leptons (14) which are characterized by $Z = 1/3$, $N = 1$ (The corresponding antiparticles of $Z = -1/3$, $N = -1$ will be denoted by $\bar{L}$). Due to the Z-conservation, the lowest antitrion $\bar{\Theta}$ cannot decay by emission of known bosons with $Z = 0$, $N = 0$. The only Z-conserving decay modes of $\bar{\Theta}$ lead to a baryon B_f and two leptons $\bar{L}$ with $Z = -1/3$, $N = -1$. These processes are assumed to be mediated by bosons Φ_x, with $Z = 2/3$, $N = 0$ and integer charge, possibly members of an undiscovered SU_3 triplet or sextet. Both representations 15 and 20″ of SO_6 contain bosons of this type [15]. We may now write the Z-conserving $\bar{\Theta}$-decays in the form

$$\bar{\Theta} \to \bar{L} + \underbrace{\Phi_x}_{\longrightarrow\ \bar{L}' + B_f.} \quad (16)$$

In particular, let us consider the decay of the $\bar{\Theta}^0$ constituents of protons by assuming that $\Phi_x = T'^0\overline{\Theta'^+}$ which is the isosinglet member of an SU_3 sextet. In this case the dominant decay modes involve processes of the type

$$\bar{\Theta}^0 \to \mu^+ + \underbrace{(T'^0\,\overline{\Theta\quad})}_{\longrightarrow\ e^- + \Xi^0,} \quad (17)$$

$$\bar{\Theta}^0 \to \mu^+ + \underbrace{(T'^0\,\overline{\Theta'^+})}_{\longrightarrow\ \nu_e + \Xi^-,} \quad (18)$$

according to the approximate hypercharge conservation. Summarizing, "direct" lepton production involves the dissociation (15) of colliding hadrons. The subsequent decays of the $\bar{\Theta}$ constituents lead directly, without the well known intermediate particles π, K . . ., to energetic leptons and a baryon B_f (e.g. Ξ^0 or Ξ^-). The baryon B_f has, in general, conventional decay modes mediated by pions, kaons etc. resulting in muons and other well known particles. We may tentatively assume that processes of the type (15)—(18) leave no energy for a muon production of pion or kaon parentage within the energy region covered by the experiment of BERGESON et al. On the other hand, processes (15)—(18) represent simple possibilities for the X processes indicated by experiments of BERGESON et al. and DARDO et al. In this way the X particles might be identified with the antitrions $\bar{\Theta}$ and the bosons Φ_x.

III. Leptonic and semileptonic weak processes

We next add some remarks to the two-triplet model of conventional leptonic and semileptonic weak interactions. Within the dynamical framework of our previous paper [15], the most simple explanation involves the hypothetical intermediate bosons $W^{\pm}$ which are supposed to be bound trion—antitrion systems. We shall not assume any strong quadratic interactions of W's with hadrons.

In [15] we suggested a relativistic field equation for trions, which governs the dynamics of the model. This equation is covariant under transformations of the Poincaré and SO_6 groups ($P \otimes SO_6$). We now suppose that the weak violations of SO_6 and parity are connected with the asymmetries of the intermediate boson states $|W^{\pm}>$, possibly due to a spontaneous mixing. As a first step of self-consistent calculations, the symmetry structure of W's will be fixed by the following requirement. The intermediate boson W^{+} must be coupled to the weak trion current (5) by the universal (P and SO_6 covariant) interaction of trions. We propose that this interaction be given by the nonlinear term of the field equation (1) of [15]. According to our requirement, the symmetry structure of W's is fixed by the following Bethe—Salpeter amplitudes

$$\langle 0 | T\mathbf{t}_m(x\alpha)\, \bar{\mathbf{t}}_n(y\beta) | W^{\pm}\rangle = \\ = \exp\left[-iq\frac{1}{2}(x-y)\right] \varphi^{\mu(W\pm)}_{\alpha m \beta n}(q; x-y)\, \tau\big(q\mu(W^{\pm})\big)\,, \tag{19}$$

where α, β are spinor indices, q is the four-momentum of the state $|W^{\pm}>$ τ is the conventional one-boson amplitude of W's, satisfying $q^{\mu}\tau(q\mu(W^{\pm})) \sim 0$ and the leading term of φ has the form

$$\varphi^{\mu(W\pm)}_{\alpha m \beta n}(q; z) = [(1+\gamma_5)\,\gamma^{\mu}]_{\alpha\beta}\, V^{(\pm|15)}_{mn}(\Theta_c)\, f^{1(W\pm)}\big(q^2, z^2, (qz)^2\big) + \ldots \,. \tag{20}$$

Note that the function $f^{1(W\pm)}$ depends only on q and the relative coordinat $z = x—y$. (The matrix $V^{(\pm|15)}$ is defined by Equ. (6)). By substituting the am plitude (20) into Equ. (70) of [15] we observe that the contribution of W's corre sponds to the effective interaction Lagrangian

$$L_w = g_w\, \bar{\mathbf{t}}\, \gamma^{\mu}(1+\gamma_5)\, V^{(+|15)}(\Theta_c)\, \mathbf{t} W^{(+)}_{\mu} + H.C. \tag{21}$$

with

$$g_w = -4\sqrt{2}\, G f^{1(W\pm)}(m_W^2, 0, 0)\,, \tag{22}$$

where m_W is the W mass and G denotes the coupling constant in the underlying field equation (1) of [15]. The form (21) verifies the structure (19)—(20) of intermediate bosons according to our requirement imposed previously. By an empirical fit of g_W and m_W the Lagrangian (21) may be regarded as a semiphenomenological basis of the CP conserving weak interactions in our SO_6 model.

Let us consider amplitudes (19)—(20). We observe that the intermediate bosons $W^{\pm}$ are of mixed parity leading to the well known parity violations in weak processes. In addition, W^{+} and W^{-} are the charged members of an isotriplet in the *weak* SO_6 space (cf. Equs. (5)—(7)). This results in hypercharge violating weak interactions of the trion constituents of hadrons which are placed in the *strong* SO_6 space. In Fig. 1 the dynamical mechanism of the model is exemplified by a schematic diagram of the process $n + \nu_\mu \to p + \mu^-$.

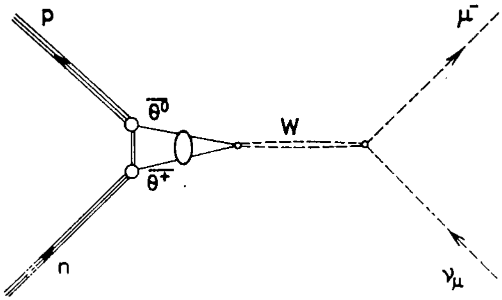

Fig. 1. Schematic diagram of the process $n + \nu_\mu \to p + \mu^-$

Finally, we shall point out some details. According to BACRY et al. [9] and GERSTEIN and WHIPPMANN [20] the known pseudoscalar bosons are to be assigned to the coregular representation 20'' in the SO_6 model. Therefore, it is convenient to express the axial vector part of the matrix elements $\langle \Theta' | J^\mu | \Theta \rangle$, contributing to the simplest β processes, in terms of the matrices $\bar{\lambda}^{j(20'')}$ which belong to representation 20'' of SO_6. These matrices are explicitly listed in [15]. We obtain

$$\begin{aligned} &\langle \Theta' | \bar{\mathbf{t}}\, \gamma^\mu (1+\gamma_5)\, V^{(\pm|15)}(\Theta_c)\, \mathbf{t} | \Theta \rangle = \\ &= \langle \Theta' | \left[\bar{\mathbf{t}} \gamma^\mu V^{(\pm|15)}(\Theta_c)\, \mathbf{t} - \bar{\mathbf{t}}\, \gamma^\mu \gamma_5 V^{(\pm|20'')}(\Theta_c)\, \mathbf{t} \right] | \Theta \rangle \end{aligned} \tag{23}$$

with

$$V^{(\pm|20'')}(\Theta_c) = \frac{\bar{\lambda}^{1(20'')} \pm i\, \bar{\lambda}^{2(20'')}}{2} \cos\Theta_c + \frac{\bar{\lambda}^{4(20'')} \pm i\, \bar{\lambda}^{5(20'')}}{2} \sin\Theta_c . \tag{24}$$

By considering the (formal) current densities

$$\mathcal{F}^{j\mu} = \bar{\mathbf{t}} \frac{\bar{\lambda}^{j(15)}}{2} \gamma^\mu \mathbf{t} , \tag{25}$$

$$\mathcal{F}_5^{j\mu} = \bar{\mathbf{t}} \frac{\bar{\lambda}^{j(20'')}}{2} \gamma^\mu \gamma_5 \mathbf{t} \tag{26}$$

for $j = 1 \ldots 8$, we may recover the chiral $SU_3 \times SU_3$ algebra in a straightforward way.

We conclude that the two-triplet model may be a useful tool for the study of various leptonic and semileptonic processes including a direct production of leptons at very high energies.

Acknowledgement

The author is very indebted to Dr. A. SOMOGYI for a valuable discussion on the Utah experiment.

REFERENCES

1. H. E. BERGESON, J. W. KEUFFEL, M. O. LARSON, E. R. MARTIN and G. W. MASON, Phys. Rev. Letters, **19**, 1487, 1967.
2. H. E. BERGESON, J. W. KEUFFEL, M. O. LARSON, G. W. MASON and J. L. OSBORNE, Phys. Rev. Letters, **21**, 1089, 1968.
3. R. J. STEFANSKI, R. K. ADAIR and H. KASHA, Phys. Rev. Letters, **20**, 950, 1968.
4. W. F. NASH and A. W. WOLFENDALE, Phys. Rev., Letters, **20**, 698, 1968.
5. J. D. BJORKEN, S. PAKVASA, W. SIMMONS and S. F. TUAN, quoted in [2].
6. C. RYAN, S. OKUBO, R. E. MARSHAK, Nuovo Cimento, **34**, 753, 1964; S. V. PEPPER, C. RYAN, S. OKUBO and R. E. MARSHAK, Phys. Rev., **137B**, 1959, 1965; S. OKUBO, Nuovo Cimento, **57A**, 794, 1968, earlier papers are quoted there.
7. W. R. SHELDON, W. G. CANTRELL and N. M. DULLER, Phys. Rev. Letters, **22**, 312, 1969.
8. Y. HARA, Phys. Rev., **134B**, 701, 1964.
9. H. BACRY, J. NUYTS and L. VAN HOVE, Nuovo Cimento, **35**, 510, 1965.
10. L. VAN HOVE in: Preludes in Theoretical Physics (Amsterdam, 1965).
11. F. GÜRSEY, T. D. LEE and M. NAUENBERG, Phys. Rev., **125B**, 467, 1964.
12. M. DARDO, P. PENENGO and K. SITTE, Nouvo Cimento, **58**A, 59, 1968.
13. E. g. J. BJORNBOE et al., Proc. Intern. Conf. Cosmic Rays, Calgary, 1967; H. KASHA and J. STEFANSKI, Phys. Rev., **172**, 1297, 1968.
14. K. LADÁNYI, Nuovo Cimento, **45**, 289, 1966.
15. K. LADÁNYI, Nuovo Cimento, **48**, 927, 1967.
16. T. D. LEE, Nuovo Cimento, **35**, 933, 1965.
17. K. MORITA, Progr. Theor. Phys., **38**, 681, 1967.
18. O. KLEIN, Phys. Rev. Letters, **16**, 63, 1966.
19. A. GAMBA, R. E. MARSHAK and S. OKUBO, Proc. Natl. Acad. Sci., **45**, 881, 1959; M. GELL-MANN, California Institute of Technology Report CTSL—20, 1961; R. GATTO, Nuovo Cimento, **27**, 313, 1963; V. GUPTA, Phys. Rev., **135B**, 783, 1964; S. OKUBO, C. RYAN and R. E. MARSHAK, Nuovo Cimento, **34**, 759, 1964; T. DAS and K. T. MAHANTHAPPA, Nuovo Cimento, **44**A, 469, 1966.
20. I. S. GERSTEIN and M. L. WHIPPMANN, Phys. Rev., **137B**, 1522, 1965.

ДВУХТРИПЛЕТНАЯ МОДЕЛЬ «НЕПОСРЕДСТВЕННОЙ» ПРОДУКЦИИ МЮОНОВ

К. ЛАДАНЬИ

Резюме

Предлагается особенная двухтриплетная модель «непосредственных» продукций лептонов, предполагая, что и лептоны и гадроны принадлежат к представлениям шестимерной ротационной группы SO_6.