A simple solution for the flavor question

Felice Pisano

Instituto de Física Teórica, Universidade Estadual Paulista

Rua Pamplona 145 - 01405-000 - São Paulo, S.P.

Brazil

Abstract

We consider a simple way for solving the flavor question by embedding the three-family Standard Model in a semisimple gauge group extending minimally the weak isospin factor. Quantum chiral anomalies between families of fermions cancel with a matching of the number of families and the number of color degrees of freedom. Our demonstration shows how the theory leads to determination of families structure when the Standard Model is the input at low energies. The new physics is limited to start below a few TeVs within the reach of the next generation colliders.

11.30.Hv, 12.15.Cc
In the Standard Model the fundamental fermions come in families. In writing down the theory one may start by first introducing just one family, then one may repeat the same procedure by introducing copies of the first family. Why do quarks and leptons come in repetitive structures (families)? How many families are there? How to understand the inter-relation between families? These are the central issues of the weak interaction physics known as the flavor question or the family problem. Nowhere in physics this question is replied. One of the most important experimental results in the past few years has been the determination of the number of these families within the framework of the Standard Model. In the minimal electroweak model the number of families is given by the number of the neutrino species which are all massless, by definition. The number of families is then computed from the invisible width of the $Z^0$,

$$
\Gamma_{\text{inv}} \equiv \Gamma_{Z^0} - (\Gamma_h + \sum_l \Gamma_l)
$$

where $\Gamma_{Z^0}$ denotes the total width, the subscript $h$ refers to hadrons and $\Gamma_l, l = \{e, \mu, \tau\}$, is the width of the $Z^0$ decay into an $ll$ pair. If $\Gamma_{\nu}$ is the theoretical width for just one massless neutrino, the number of families is

$$
N_{\text{fam}} = N_{\nu} = \frac{\Gamma_{\text{inv}}}{\Gamma_{\nu}}
$$

and recent results give a value very close to three

$$
N_{\text{fam}} = 2.99 \pm 0.03
$$

but we don’t understand why the number of standard families is three. The answer to the flavor question may require a radical change in our approaches. It could be that the underlying objects are strings and all the low energy phenomena will be determined by physics at the Planck scale. Grand Unified Theories (GUT) have had a major impact on both Cosmology and Astrophysics; for Cosmology they led to the inflationary scenario, while for Astrophysics supernova neutrinos were first observed in proton-decay detectors. It remains for GUTs to have impact directly on particle physics itself. GUTs cannot
explain the presence of fermion families. On the other side, supersymmetry for the time being is an answer in search of question to be replied. It doesn’t explain the existence of any known particle or symmetry. Some traditional approaches to the problem such as GUTs, monopoles and higher dimensions introduce quite speculative pieces of new physics at high and experimentally inaccessible energies. Some years ago there were hopes that the number of families could be computed from first principles such as geometry of compactified manifolds but these hopes did not materialize. The Standard Model works so well, that there is, at present, no experimental evidence for new physics beyond the Standard Model. Of course, this does not mean that there is no new physics.

We wish to suggest here that some very fundamental aspects of the Standard Model, in particular the flavor question, might be understood by embedding the three-family version in a Yang-Mills theory with the gauge semisimple group \[ G_{331} \equiv SU(3)^C \otimes SU(3)_L \otimes U(1)_N \]

with a corresponding enlargement of the quark representations. In particular, the number of families will be related by anomaly cancellation to the number of quark colors. In the low-energy limit all three families appear similar and cancel anomalies separately. The \( G_{331} \) model is a dilepton gauge theory which is chiral and has nontrivial anomaly cancellation. This novel method of anomaly cancellation requires that at least one family transforms differently from the others, thus breaking generation universality. Unlike the \( G_{321} \) Standard Model, where anomalies cancel family by family, anomalies in the \( G_{331} \) model only cancel when all three families are taken together. With this meaning we present here the simplest solution for the flavor question just enlarging the SU(2)\(_L\) weak isospin group to SU(3)\(_L\). This does not explain why \( N_{\text{fan}} > 1 \) for the number of families but is sufficiently impressive to suggest that \( N_{\text{fan}} = 3 \) may be explicable by anomaly cancellation in the simplest gauge extension of the Standard Model with a very particular representation content. The electroweak gauge group extension from SU(2) to SU(3) will add five gauge bosons. The adjoint
gauge octet of SU(3) breaks into \( 8 = 3 + (2 + 2) + 1 \) under SU(2). The 1 is a \( Z' \) and the two doublets are readily identifiable from the leptonic triplet or antitriplet \((\nu_l, l^-, l^+)\) as dilepton gauge bosons \((U^-, V^-)\) and \((U^+, V^+)\). Such dileptons appeared first in stable-proton GUT [7] but there the fermions were non-chiral and one needed to invoke mirror fermions; this is precisely what is avoided in the \(G_{331}\) model. Contrary to the GUT case, there is no “grand desert” if \(G_{331}\) models are realized in nature and new physics could arise at not too high energies, say in the TeV range [8].

We start with the way the electric charge operator \(Q\) is embedded in the neutral generators of the SU(3)\(_L\) group. The fermion contents depend on the electric charge operator

\[
Q = \frac{1}{2}(\lambda_3^L + \xi \lambda_8^L) + N
\]

where \(\lambda_{3,8}^L\) are the neutral generators of SU(3)\(_L\), \(\xi\) is the embedding parameter and \(N\) is the U(1)\(_N\) charge proportional to the unit matrix. The SU(3)\(_L\) generators are normalized as \(\text{Tr}(\lambda_a^L \lambda_b^L) = 2\delta_{ab};\ a, b = 1, 2, ..., 8\). In the \(G_{331}\) models with lepton charges 0, \(\pm 1\) there is always a set of families transforming as \((1, 3, 0)\) under the gauge group. In these families there is charge quantization in the sense of GUTs; the electric charge operator is a linear combination of the simple group generators.

In the \(\xi = -\sqrt{3}\) model [5] three families of leptons belong to representation

\[
\psi_{1L} \equiv \begin{pmatrix} \nu_l \\ l \\ l^c \end{pmatrix}_L \sim (1, 3, N\psi_{1L} = 0); \ l = e, \mu, \tau
\]

where \(l^c = C l^T\) and \(C\) being the charge conjugation matrix. The right-handed neutrinos may be included in the theory if desired [5]. A result of this embedding is that there are no new leptons in the \(G_{331}\) model. While all three lepton families are treated identically, anomaly cancellation requires that one of the quark families transforms differently from the other two. In particular, canceling the pure SU(3)\(_L\) anomaly requires that there are the same number of triplets and antitriplets. Taking into account the three quark color degrees of freedom we must introduce the multiplets of chiral quarks
\[ Q_{1L} \equiv \begin{pmatrix} u \\ d \\ J \end{pmatrix}_L \sim (3, 3, N_{Q_{1L}}); \quad Q_{23L} \equiv \begin{pmatrix} j_1, j_2 \\ c, t \\ s, b \end{pmatrix}_L \sim (3, 3^*, N_{Q_{23L}}) \] (5)

with the respective right-handed fields in SU(3)_L singlets,

\begin{align*}
&u_R \sim (3, 1, N_{u_R}), \quad c_R \sim (3, 1, N_{c_R}), \quad t_R \sim (3, 1, N_{t_R}); \\
d_R \sim (3, 1, N_{d_R}), \quad s_R \sim (3, 1, N_{s_R}), \quad b_R \sim (3, 1, N_{b_R}),
\end{align*}
(6)

and the exotic quarks

\begin{align*}
&J_R \sim (3, 1, N_{J_R}), \quad j_{1R} \sim (3, 1, N_{j_{1R}}), \quad j_{2R} \sim (3, 1, N_{j_{2R}})
\end{align*}
(7)

where we have suppressed the color index. We are dealing with a gauge theory of chiral fermions. There are two quite distinct ways in which the \( G_{331} \) model establish the inter-relation between fermion families. Firstly, there are a set of constraints which follow from the consistency of the theory at the classical level, such as the requirement that the Lagrangian be gauge invariant, while there are other constraints which follow from the consistency of the theory at the quantum level which are the anomaly cancellation conditions. Anomalies imply the loss of a classical symmetry in the quantum theory \([10]\). For chiral gauge theories in four dimensions our basic tool will be freedom from the triangle perturbative chiral gauge anomaly which must be canceled to avoid the breakdown of gauge invariance and the renormalizability of the theory. Of course, it is clear that anomalies alone cannot lead to a definite theory without some way to specify the underlying chiral fermions and some knowledge of the gauge symmetry that is responsible for the dynamics.

Let us first obtain the classical constraints. In order to generate Yukawa couplings we introduce the minimal set of scalar fields SU(3)_L triplets \( \eta \sim (1, 3, N_{\eta}) \), \( \rho \sim (1, 3, N_{\rho}) \), and \( \chi \sim (1, 3, N_{\chi}) \). The Yukawa Lagrangian, without considering the mixed terms between quarks is

\begin{align*}
-\mathcal{L}_Y &= \bar{Q}_{1L}(G_u u_R \eta + G_d d_R \rho + G_J J_R \chi) + (G_c \bar{Q}_{2L} c_R + G_t \bar{Q}_{3L} t_R) \rho^* \\
&\quad + (G_s \bar{Q}_{2L} s_R + G_b \bar{Q}_{3L} b_R) \eta^* + (G_{j_1} \bar{Q}_{2L} j_{1R} + G_{j_2} \bar{Q}_{3L} j_{2R}) \chi^* + \text{H.c.}
\end{align*}
(8)
where all fields are weak eigenstates and \( \eta^*, \rho^*, \chi^* \) denote the respective antitriplets \([11]\).

The requirement of gauge invariance leads to the classical constraints

\[
N_{Q_{1L}} - N_{u_R} = N_{\eta}
\]
\[N_{Q_{1L}} - N_{d_R} = N_{\rho}
\]
\[N_{Q_{1L}} - N_{J_R} = N_{\chi}
\]

for the first family and

\[
N_{Q_{2L}} - N_{j_{1R}} = N_{\chi^*}
\]
\[N_{Q_{2L}} - N_{c_R} = N_{\rho^*}
\]
\[N_{Q_{2L}} - N_{s_R} = N_{\eta^*}
\]

for the second family. The constraints for the third family are obtained from those of the second family making the replacements \( Q_{2L} \rightarrow Q_{3L}, j_{1R} \rightarrow j_{2R}, c_R \rightarrow t_R, \) and \( s_R \rightarrow b_R \). The above equations with \( N_{\eta^*} = -N_{\eta}, N_{\rho^*} = -N_{\rho}, \) and \( N_{\chi^*} = -N_{\chi} \) imply

\[
N_{Q_{1L}} + N_{Q_{2L}} = N_{u_R} + N_{s_R}
\]
\[N_{Q_{1L}} + N_{Q_{2L}} = N_{d_R} + N_{c_R}
\]
\[N_{Q_{1L}} + N_{Q_{2L}} = N_{j_{1R}} + N_{J_R}
\]

constraining the first and second families and

\[
N_{Q_{2L}} - N_{Q_{3L}} = N_{j_{1R}} - N_{j_{2R}}
\]
\[N_{Q_{2L}} - N_{Q_{3L}} = N_{c_R} - N_{t_R}
\]
\[N_{Q_{2L}} - N_{Q_{3L}} = N_{s_R} - N_{b_R}
\]

which relates the second and third families. This step illustrates how the Lagrangian is used as the primary source of constraints.

Let us now consider the quantum constraints. It will be sufficient to consider only anomalies which contain \( U(1)_N \) factors

6
\[ \text{Tr}[SU(3)_{C}]^{2}[U(1)_{N}] = 0 : \]

\[ 3 \left( N_{Q_{1L}} + N_{Q_{2L}} + N_{Q_{3L}} \right) - N_{u_{R}} - N_{c_{R}} - N_{t_{R}} \]
\[ - N_{d_{R}} - N_{s_{R}} - N_{b_{R}} - N_{j_{R}} - N_{j_{1R}} - N_{j_{2R}} = 0 \]  
(13)

\[ \text{Tr}[SU(3)_{L}]^{2}[U(1)_{N}] = 0 : \]

\[ 3 \left( N_{Q_{1L}} + N_{Q_{2L}} + N_{Q_{3L}} \right) + N_{\psi_{eL}} + N_{\psi_{\mu L}} + N_{\psi_{\tau L}} = 0 \]  
(14)

\[ \text{Tr}[U(1)_{N}]^{3} = 0 : \]

\[ 3 \left( N_{Q_{1L}}^{3} + N_{Q_{2L}}^{3} + N_{Q_{3L}}^{3} \right) - N_{u_{R}}^{3} - N_{c_{R}}^{3} - N_{t_{R}}^{3} \]
\[ - N_{d_{R}}^{3} - N_{s_{R}}^{3} - N_{b_{R}}^{3} - N_{j_{R}}^{3} - N_{j_{1R}}^{3} - N_{j_{2R}}^{3} \]
\[ + N_{\psi_{eL}}^{3} + N_{\psi_{\mu L}}^{3} + N_{\psi_{\tau L}}^{3} = 0 \]  
(15)

\[ \text{Tr}[\text{graviton}]^{2}[U(1)_{N}] = 0 : \]

\[ 3 \left( N_{Q_{1L}} + N_{Q_{2L}} + N_{Q_{3L}} \right) - N_{u_{R}} - N_{c_{R}} - N_{t_{R}} \]
\[ - N_{d_{R}} - N_{s_{R}} - N_{b_{R}} - N_{j_{R}} - N_{j_{1R}} - N_{j_{2R}} \]
\[ + N_{\psi_{eL}} + N_{\psi_{\mu L}} + N_{\psi_{\tau L}} = 0 \]  
(16)

where the first three anomalies are the familiar triangle gauge-anomalies and the last condition in Eq. (16) is a little more speculative in that it arises from a triangle graph with two external gravitons and one $G_{331}$ gauge boson. Whatever the correct quantum gravity theory is, the “mixed gauge-gravitational” anomaly must be cancelled for consistency. If one believes in quantum gravity, then one may also wish to impose the requirement that the mixed gauge-gravitational anomaly cancel. Notice that in contrast to the minimal Standard Model, the classical and the quantum constraints enclose all three families of fermions. As it was said before, the quark representations in Eqs. (5) - (6) are symmetry eigenstates; that is, they are related to the mass eigenstates by Cabibbo-like angles. As we have one
triplet and two antitriplets, it should be expected that flavor-changing neutral currents exist. However when we determine the neutral currents explicitly we find that all of them, for the same charge sector, have equal factors and the Glashow-Iliopoulos-Maiani [13] cancellation is automatic in neutral currents coupled to $Z^0$ [13]. Although each family is anomalous, this type of construction is only anomaly-free when the number of families is divisible by the number of colors. Thus three families are singled out as the simplest nontrivial anomaly-free $G_{331}$ model.

The flavor question of the Standard Model might be understood by embedding the three family version in the $G_{331}$ group with a corresponding enlargement of the quark representations. In the $G_{331}$ low-energy limit all three families appear similarly and cancel anomalies separately. By matching the coupling constants at the $G_{331}$ symmetry breaking an upper limit on the symmetry-breaking scale of a few TeVs can be placed by the requirement that $\sin^2 \theta_W < 1/4$, implying that the physics associated with the $(U^{\pm \pm}, V^{\pm})$ dilepton gauge bosons, the additional $Z'$ neutral gauge boson, and the $J, j_{1,2}$ exotic quarks will be accessible to the next generation of colliders [8,14]. The Standard Model is the effective low energy theory of the $G_{331}$ model and it enjoys considerable support from experiment. As such we can take it to be a safe input to $G_{331}$. According to Eq. (4) we have directly $N_{\psi l L} = 0$ for any leptonic family $l = e, \mu, \tau$. Let us set the following notation

$$N_{u R} = N_{c R} = N_{t R} \equiv N_{U R},$$

$$N_{d R} = N_{s R} = N_{b R} \equiv N_{D R}$$

and from the constraints given in Eqs. (12) we obtain the following two conditions

$$N_{Q 2 L} = N_{Q 3 L} \equiv N_{Q \alpha L}, \quad \alpha = 2, 3;$$

and

$$N_{J 1 R} = N_{J 2 R} \equiv N_{J R}.$$ 

Thus we write the quantum constraints of Eqs. (13) - (16) in the concise form

8
\[ \text{Tr}[\text{SU}(3)_C]^2[\text{U}(1)_N] = 0 : \]

\[ 3(N_{Q_1L} + 2N_{Q_{aL}}) - 3(N_{U_R} + N_{D_R}) - N_{J_R} - 2N_{j_R} = 0 \]  

(21)

\[ \text{Tr}[\text{SU}(3)_L]^2[\text{U}(1)_N] = 0 : \]

\[ 3(N_{Q_1L} + 2N_{Q_{aL}}) = 0 \]  

(22)

\[ \text{Tr}[\text{U}(1)_N]^3 = 0 : \]

\[ 3(N_{Q_1L}^3 + 2N_{Q_{aL}}^3) - 3(N_{U_R}^3 + N_{D_R}^3) - N_{J_R}^3 - 2N_{j_R}^3 = 0 \]  

(23)

and the mixed gravitational-gauge constraint coincides with the \([\text{SU}(3)_C]^2[\text{U}(1)_N]\) anomaly.

In the new notation the classical constraints given in Eqs. (11) becomes

\[ N_{Q_1L} + N_{Q_{2L}} = N_{U_R} + N_{D_R}, \]

\[ N_{Q_1L} + N_{Q_{2L}} = N_{J_R} + N_{J_R}. \]  

(24)

From these classical constraints we obtain

\[ N_{U_R} + N_{D_R} = N_{J_R} + N_{J_R} \]  

(25)

which through Eq. (22) the quantum constraint of Eq. (21) gives a relation between \(N\)-charges of the exotic quarks

\[ 4N_{J_R} + 5N_{j_R} = 0 \]  

(26)

and from Eq. (25) we find

\[ N_{U_R} + N_{D_R} = \frac{1}{5}N_{J_R}. \]  

(27)

If the Standard Model is the input at low energies we know that

\[ N_{U_R} = \frac{2}{3} \text{ and } N_{D_R} = -\frac{1}{3} \]  

(28)
and then from Eqs. (26) and (27) we obtain the electric charges of the exotic quarks

\[ N_{J_R} = \frac{5}{3} \quad \text{and} \quad N_{J_R} = -\frac{4}{3}. \tag{29} \]

At this stage it is also possible to establish the last U(1)\(_N\) charges of the new \(G_{331}\) attributions.

Let us take the quantum constraint of Eq. (22)

\[ N_{Q_{1L}} = -2N_{Q_{\alpha L}} \tag{30} \]

and the cubic quantum constraint of Eq. (23) which, in turn, may be related to give

\[ N_{Q_{1L}} = \frac{2}{3} \tag{31} \]

and

\[ N_{Q_{\alpha L}} = -\frac{1}{3}, \quad \alpha = 2, 3 \tag{32} \]

for the three families of chiral left-handed quarks.

The \(G_{331}\) model is indistinguishable from the Standard Model at low energies. In this class of models in order to cancel anomalies the number of families, \(N_{\text{fam}}\), must be divisible by the number of colors degrees of freedom, \(N_C\). Hence the simplest possibility is \(N_{\text{fam}}/N_C = 1\). Concerning the fermion representation content the salient features of \(G_{331}\) model can be summarized as 1) half the number of fermions are put in the SU(3)\(_L\) triplet representation and the other half in the antitriplet representation; 2) the triangle anomalies cancel between families which gives the first step to understand the flavor question; 3) the anomaly cancellation takes place when the number of families is an integer factor of the number of quark colors; 4) a different treatment of one quark family than the other two. In particular, a singularity of the third family \([6]\) may give us some indication as to why the top flavor is so heavy and it may present a new approach for the question of fermion mass generation \([15]\); 5) the existence of new heavy quark flavors at energy scales that are higher than those relevant for the Standard Model. For all appearances this is a trash but if the cross-section \(\sigma(pp \rightarrow t\bar{t} + X)\) obtained by the CDF Collaboration \([16]\) is in fact higher than the prediction of quantum chromodynamics, this may be a signature of new quarks.
An interesting fact concerns the generalization from SU(3)$_L$ to SU(4)$_L$. Using again the lightest leptons as the particles which determine the approximate symmetry, if each family is treated separately, SU(4) is the highest symmetry group to be considered in the electroweak sector \([7]\). In this sense this is the maximal generalization of \(G_{331}\) model. There is no room for SU(5)$_L \otimes$ U(1) if the nature restrict to the case of leptons with 0, ±1 electric charges.

From the renormalization group analysis of the gauge coupling constants, the breaking scale is estimated to be 1.7 TeV or lower \([3]\). We, therefore, expect the masses of dilepton gauge bosons and the three flavor exotic quarks to be around or less than 1 TeV. The prospects of searching for dilepton gauge bosons was considered recently \([18]\) where the cross section for the process \(e^- p \rightarrow e^+ + \) anything mediated by doubly-charged dileptons at HERA with \(\sqrt{s} = 314\) GeV and an integrated luminosity 100 pb\(^{-1}\) could indicate the signature of dileptons with mass up to 340 GeV (650 GeV) if the new \(j\) quark has a mass lighter than 200 GeV (150 GeV). At LEPII-LHC with \(\sqrt{s} = 1790\) GeV and an anticipated annual luminosity 6 fb\(^{-1}\)yr\(^{-1}\), at least 280 events per year can be expected unless both the masses of dileptons and of the \(j\)-quark are heavier than 1 TeV. The \(j\) or \(\bar{j}\) quarks may also be produced in powerful \(pp\) colliders such as LHC, through the process gluon + gluon \(\rightarrow j + \bar{j}\). The signal for a produced \(j\)-quark is characterized by 1 jet + 2 leptons, since the \(j\) quark decays as \(j \rightarrow u + l^- + l^-\) through \(U^-\) exchange or as \(j \rightarrow d + l^- + \nu_l\) through \(V^-\) exchange. Indeed, much of the appeal of the \(G_{331}\) model is that the new physics is guaranteed to be below a few TeV, well within the reach of future colliders. Finally, could be that 331 models are not just an embedding of the Standard Model but an alternative to describe these same interactions and new ones.

ACKNOWLEDGMENTS

I would like to thank the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for a research fellowship.
REFERENCES

[1] S.L. Glashow, Nucl. Phys. 22, 279 (1961); S. Weinberg, Phys. Rev. Lett. 19, 1264 (1967); A. Salam, in Proceedings of the VIII Nobel Symposium, Edited by N. Svartholm (Almqvist and Wiksell, Stockholm, 1968) 367; H. Fritzsch, M. Gell-Mann and H. Leutwyler, Phys. Lett. B 47, 365 (1973).

[2] S.L. Glashow, in The Unity of the Fundamental Interactions, Edited by A. Zichichi, (Plenum Press, 1983) 14.

[3] T. Riemann and J. Blumlein, Proceedings of the Zeuthern Workshop on Elementary Particles [Nucl. Phys. B (Proc. Suppl.) 37B (1994)].

[4] R. Foot and H. Lew, Nuovo Cimento 104A, 167 (1991).

[5] F. Pisano and V. Pleitez, Phys. Rev. D 46, 410 (1992); R. Foot, O.F. Hernandez, F. Pisano and V. Pleitez, Phys. Rev. D 47, 4158 (1993).

[6] P.H. Frampton, Phys. Rev. Lett. 69, 2889 (1992).

[7] P.H. Frampton and B.H. Lee, Phys. Rev. Lett. 64, 619 (1990); P.B. Pal, Phys. Rev. D 43, 236 (1991).

[8] D. Ng, Phys. Rev. D 49, 4805 (1994).

[9] P.H. Frampton, P.I. Krastev and J.T. Liu, Mod. Phys. Lett. A 9, 761 (1994).

[10] S. Adler, Phys. Rev. 177, 2426 (1969); J.S. Bell and R. Jackiw, Nuovo Cimento 60A, 49 (1969).

[11] J.C. Montero, F. Pisano and V. Pleitez, Phys. Rev. D 47, 2918 (1993).

[12] R. Delbourgo and A. Salam, Phys. Lett. B 40, 381 (1972); L. Alvarez-Gaumé and E. Witten, Nucl. Phys. B 234, 269 (1983).

[13] S.L. Glashow, J. Iliopoulos and L. Maiani, Phys. Rev. D 2, 1285 (1970).
[14] D.G. Dumm, F. Pisano and V. Pleitez, Mod. Phys. Lett. A 9, 1609 (1994).

[15] J.T. Liu, Phys. Rev. D 50, 542 (1994); J.T. Liu and D. Ng, Phys. Rev. D 50, 548 (1994).

[16] CDF Collaboration, F. Abe et al., Phys. Rev. Lett. 73, 225 (1994).

[17] M.B. Voloshin, Sov. J. Nucl. Phys. 48, 512 (1988); R. Foot, H.N. Long and T.A. Tran, Phys. Rev. D 50, R34 (1994); F. Pisano and V. Pleitez, Phys. Rev. D 51, 3865 (1995).

[18] K. Sasaki, K. Tokushuku, S. Yamada and Y. Yamazaki, Phys. Lett. B 345, 495 (1995).