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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
YEREVAN PHYSICS INSTITUTE

R.A. ALANAKYAN

SCALAR LEPTOQUARKS AND Z^0-BOSON DECAYS WITH LEPTON FLAVOUR VIOLATION

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ՍԿԱԼՅԱՐ ԼԵՊՏՈՔՎԱՐԿՆԵՐ ԵՎ Z^0-ԲՈԶՈՆՆԵՐԻ ՏՐՈՀՈՒՄՆԵՐԸ ԼԵՊՏՈՆԻ ԲՈՒՅՐԻ ԽԱԽՏՄԱՄԲ

E_6 գերլարի մոդելի շրջանակներում հետապնդված են Z^0- բոզոնի տրոհումները լեպտոնի բույրի խախտմամբ ($Z^0 \to \mu e, \mu\tau, e\tau$)՝ առաջացող սկալյար լեպտոքվարկների փոխանակման հաշվին։ Լեպտոքվարկի և լեպտոնի Յուկավայի կապի λ հաստատուն $\sim 10^{-1}$ և $M=200$ ԳէՎ լեպտոքվարկի զանգվածի դեպքում տրոհման համար ստացված է $Br(Z^0 \to \mu^+e^- + \mu^-e^+) \sim 10^{-10}$։

Երևանի Ֆիզիկայի Ինստիտուտ
[illegible]

Препринт ЕФИ-1289(75)-90

Р. А. АЛАНАКЯН

СКАЛЯРНЫЕ ЛЕПТОКВАРКИ И РАСПАДЫ Z^0-БОЗОНОВ С НАРУШЕНИЕМ ЛЕПТОННОГО АРОМАТА

В рамках E_6-модели суперструны изучены распады Z^0-бозона с нарушением лептонного аромата ($Z^0 \to \mu e$, $\mu\tau$, $e\tau$), происходящие за счет обмена скалярными лептокварками. Для юкавской константы связи λ лептокварка с кварками и лептонами $\sim 10^{-1}$ и массы лептокварка M=200 ГэВ имеем долю распада
$Br(Z^0 \to \mu^+ e^- + \mu^- e^+) \sim 10^{-10}$.

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R.A. ALANAKYAN

SCALAR LEPTOQUARKS AND Z^o-BOSON DECAYS WITH LEPTON FLAVOUR VIOLATION

The decays of the Z^o-bosons with lepton flavour violation ($Z^o \to \mu e, \mu\tau, e\tau$) are studied in the framework of superstring-inspired E_6 model. For Yucawa coupling λ leptoquark with quarks and leptons $\sim 10^{-1}$ and for leptoquarks mass M=200 GeV we have $Br(Z^o \to \mu^+ e^- + \mu^- e^+) \sim 10^{-10}$.

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Leptoquarks are colour triplets converting quarks into leptons via Yucawa couplings; they appear in many theories beyond standard model and, in E_6 superstring model [1-6] in particular. Within the framework of this model leptoquarks are contained in E_6 fundamental representation and are colour triplet, SU(2) singlet with charge $Q=-\frac{1}{3}$ and have masses M≤1TeV. The interaction of leptoquarks with quarks and leptons is described by superpotential (see for example [7])

$$W = \lambda_1^{ijk} h_i^c L_j^a \varepsilon_{ab} Q_k^b + \lambda_2^{ijk} h_i l_j^c U_k^c ,$$

where $L = (\nu_l, l)$, $Q=(u,d)$ are left doublets, l^c and u^c correspond to right singlet and ε_{ab} is antisymmetric tensor (a,b=1,2). Superfields h and h^c contain the scalar fields h_L and h_R which are scalar leptoquarks, and which we shall call left and right accordingly. In this formula i,j,k = 1,2,3 are generation indices. The couplings $\lambda_{1,2}^{ijk}$ are arbitrary, and at their expense quark of one generation can convert into quark of another generation and vice versa.

In this paper we consider Z^0-boson decays into lepton pair with different flavour via leptoquark exchange. Our research of such decays is conditioned by their convenience for observation, and their smallness in standard model framework present certain interest in search of phenomena beyond the standard model. So $Z \to \mu e$ ($\mu\tau, e\tau$) decays could be caused by the mixing of different scalar neutrino generations[8].

Four diagrams corresponding to the left scalar leptoquark exchange are given in Fig.1. The same diagrams correspond to exchange of the right scalar leptoquark. The spinor leptoquark contribution as well as the possible mixing of the left and right scalar leptoquark are not taken into account.

Although Yucawa couplings are completely arbitrary, for certainty we consider, that $\lambda_{1,2}^{i1k} = \lambda_{1,2}^{i2k} = \lambda_{1,2}^{L3k}$, then $Z \to \mu e, \mu\tau, e\tau$ decays are identical to each other (masses of the lepton being neglected). Besides, every time we take into account only the contribution of one quark flavour. For example, if we speak about t-quark, then we consider that $\lambda = \lambda_{1,2}^{ij3} \gg \lambda_{1,2}^{ij1}, \lambda_{1,2}^{ij2}$ etc., although such an assumption is arbitrary, and all three quarks u,c and t contribute to the amplitude.

Dimensional regularization was used for the amplitude calculation[9].

The amplitude corresponding to each of the diagrams is divergent, however, the total amplitude is finite

$$M = \frac{ie\sin\theta w}{2\cos\theta w} \lambda^2 \frac{1}{16\pi^2} F_1(M,m) \bar{U}_\mu \hat{Z}(1+\gamma_5) V_{e^+} ,$$

$$+ \frac{ie\sin\theta w}{2\cos\theta w} \lambda^2 \frac{1}{16\pi^2} F_2(M,m) \bar{U}_\mu \hat{Z}(1-\gamma_5) V_{e'} ,$$

where Z_μ is polarisation vector of the Z^0- boson. The first term corresponds to the left leptoquark contribution, and the second term corresponds to the right leptoquark contribution. Here M is leptoquark mass, and m is quark mass. The representation of the functions $F_1(M,m)$ and $F_2(M,m)$ is shown in Figs.2,3.

The behaviour of the branching ratios ($Br(Z^o\to \mu e) = 2\Gamma(Z^o\to\mu^- e^+)/\Gamma_{tot}$) for cases of the left and right leptoquarks is represented separately in Figs.4,5. (The left and right leptoquarks contribution don't interfere with each other).

It is clear from these figures that the left and right leptoquarks contributions are of the same order. In case of the left leptoquarks the t-quark contribution considerably surpasses the light quark contributions and in case of the right leptoquarks these contribution are approximately of the same order. It is obvious that this decay widths are very small. So, for $\lambda\sim 10^{-1}$ and M = 200 GeV we get $Br(Z^o\to\mu e)\sim 10^{-10}$, i.e. the observation of such process lies beyond LEP possibilities.

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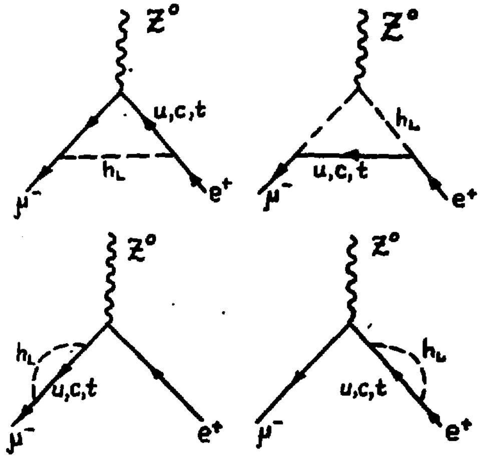


Fig.1

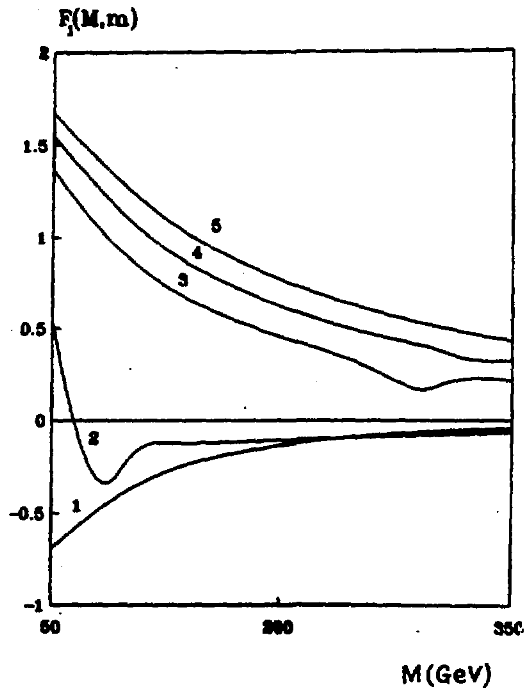


Fig.2

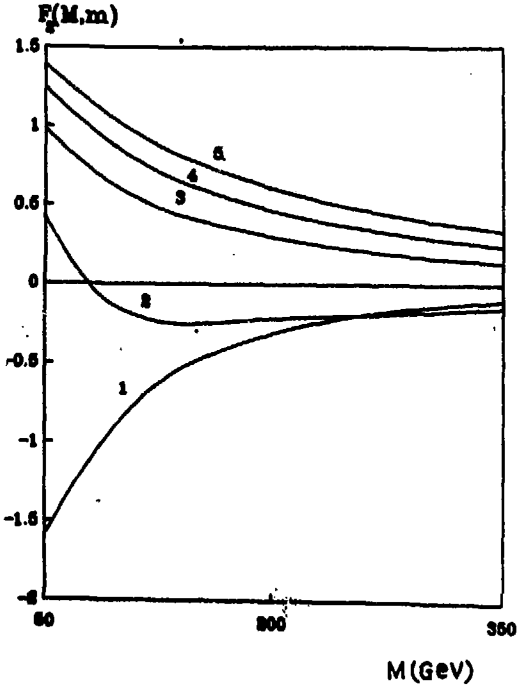
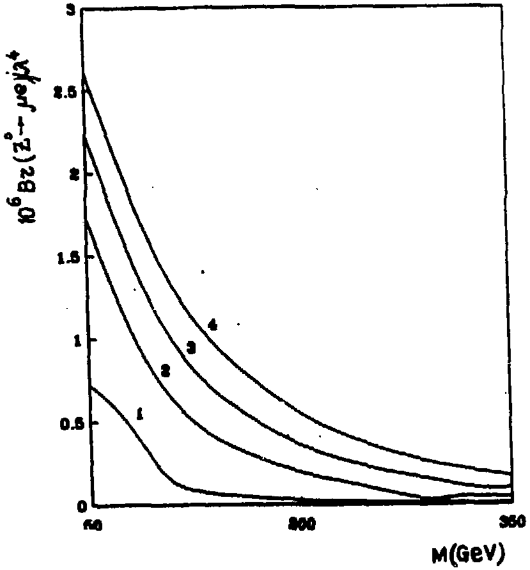

F(M,m)
1.5
1
0.5
0
-0.5
-1
-1.5
-2
50
200
350
M(GeV)
1
2
3
4
5

Fig.3


3
2.5
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1.5
1
0.5
0
50
200
350
M(GeV)
1
2
3
4

Fig. 4

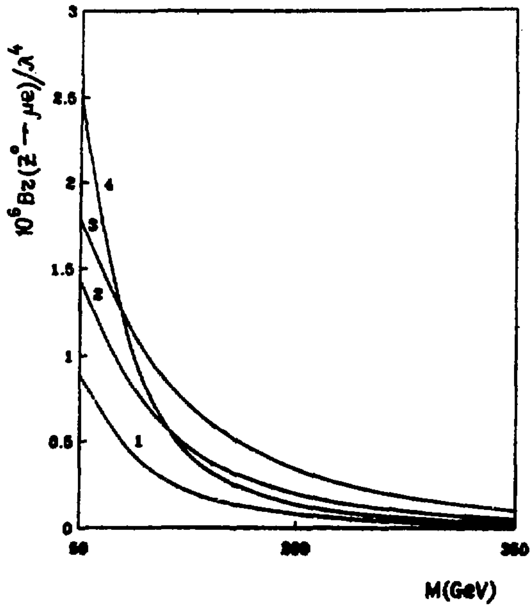

Fig.5

Figure Captions

Fig.1. Diagrams describing $Z^o \rightarrow \mu e$ decay.

Fig.2. The dependence of the $F_1(M,m)$ on the leptoquark mass. Curves 1,2,3,4 and 5 correspond to $ImF_1(M,0)$, $ReF_1(M,75GeV)$, $ReF_1(M,100\ GeV)$ and $ReF_1(M,125\ GeV)$.

Fig.3. The dependence of the $F_2(M,m)$ on the leptoquark mass, Curves 1,2,3,4 and 5 correspond to $ImF_2(M,0)$, $ReF_2(M,0)$, $ReF_2(M,75GeV)$, $ReF_2(M,100GeV)$ and $ReF_2(M,125\ GeV)$.

Fig.4. The dependence on M for branching ratio $Z^o \rightarrow \mu e$ divided by factor λ^4 via exchange the left scalar leptoquark. Curves 1,2,3,4 correspond to m=0; 75; 100; 125 GeV respectively.

Fig.5. The dependence on M for the branching ratio $Z^o \rightarrow \mu e$ divided by factor λ^4 via exchange the right scalar leptoquark. Curves 1,2,3,4 correspond to m=75;100;125;0 GeV respectively.

References

1. Gross D.J., Harvey J.A., Martinec E., Rohm R., Nucl.Phys., 1985, B256, 253.
2. Gross D.J., Harvey J.A., Martinec E., Rohm R., Nucl.Phys., 1986, B267, 75.
3. Candelas P., Horowitz G.T., Strominger A., Witten E., Nucl.Phys., 1985, B258, 46.
4. Witten E., Nucl.Phys., 1985, B 258, 75.
5. Dine M., Kaplunovsky V., Mangano M., et al., Nucl.Phys., 1985, B259, 519.
6. Breit J., Ovrut B.A., Segre' G., Phys.Lett., 1985, B 158, 33.
7. Barger V., Deshpande N.G., Hagiwara K., Phys.Rev. 1987, D 36, 3541.
8. Levine M.J.S., Phys.Rev., 1987, D.36, 1329.
9. t'Hooft G., Veltman M., Nucl.Phys., 1972, B 44, 189.

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The address for requests:
Information Department
Yerevan Physics Institute
Alikhanian Brothers 2,
Yrevan, 375036
Armenia, USSR

Р. А. АЛАНАКЯН

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