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ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

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SUPERUNIFICATION MODEL SO(10)

ЦНИИатоминформ

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SO(10) ՍՈՒՊԵՐՄԻԱՎՈՐՄԱՆ ՄՈԴԵԼ

Առաջարկվում է սուպերմիավորման մոդել՝ հիմնված SO(10) խմբի վրա: $SU(3)_c \times U(1)_{B-L} \times SU(2)_R \times SU(2)_L$ միջանկյալ համաչափությունը և սուպերհամաչափությունը խախտված են մեկ մասշտաբային պարամետրի օգնությամբ: Սովորական մասնիկների սուպերզույգերը ստանում են զանգվածներ՝ շնորհիվ ռադիացիոն ճշտումների հաշվառման: Նմանապես, էլեկտրաթույլ խմբի խախտումը ծեռք է բերվում, երբ հաշվի է առնվում սկալյար $SU(2)_L$ զույգերի զանգվածների վրա ռադիացիոն ճշտումները:

Ստացված է առնչություն t քվարկի զանգվածի և ֆերմիոնների սուպերզույգերի զանգվածների միջև: 40 ԳէՎ-ին հավասար t քվարկի զանգվածի դեպքում սուպերզույգերի զանգվածները գտնվում են 150-180ԳէՎ-ի շրջակայքում: Տրամաչափային բոզոնների սուպերզույգերի զանգվածների համար ստացված առնչությունը կարող է օգտակար լինել պրոտոնի կյանքի տևողությունը գնահատելու համար:

Երևանի ֆիզիկայի ինստիտուտ

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Г.М.АСАТРЯН, А.Н.ИОАННИСЯН

МОДЕЛЬ СУПЕРОБЪЕДИНЕНИЯ SO(I0)

Предлагается модель суперобъединения, основанная на группе SO(I0). Суперсимметрия и промежуточная симметрия $SU(3)_c \times U(I)_{B-L} \times SU(2)_R \times SU(2)_L$ нарушаются с помощью одного масштабного параметра. Суперпартнеры обычных частиц получают массы благодаря учету радиационных поправок. Нарушение электрослабой группы также достигается после учета радиационных поправок к массам скалярных $SU(2)_L$ - дублетов. Получено соотношение, связывающее массу t кварка с массами суперпартнеров фермионов: при массе t - кварка, равной 40 ГэВ, массы суперпартнеров находятся в районе I50-I80 ГэВ. Соотношение, полученное для масс суперпартнеров калибровочных бозонов может быть полезно для оценки времени жизни протона.

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quantum corrections, when $SU(2)_L$ doublets of Higgs fields acquire negative mass square at low energies.

The simplest superunification model is based on the group SU(5). Realistic SU(5) models based on the above described breaking mechanism, are developed in Refs.[8,9] .

In the present paper a superunification model is proposed based on the group SO(10). The fact that SO(10) contains a higher symmetry than SU(5) does, in particular, involves the Pati-Salam group SU(4), allows to solve the problem of breaking of the electroweak subgroup in a more natural way. In our model as well as in Refs.[6-9] the masses of superpartners of ordinary particles are obtained only after the account of quantum corrections: the masses of superpartners of quarks and leptons are given by three-loop diagrams, and the masses of the gauge boson superpartners by two-loop diagrams. These diagrams succeed to be evaluated. The corresponding choice of parameters allows one to obtain the negative mass square for the Weinberg--Salam doublets of the Higgs fields. From the analysis of the Higgs field potential we obtain an interesting relation, which connects the t-quark mass with those of the fermion superpartners. The obtained results for gauge-boson superpartners masses can be useful for estimations of the proton lifetime.

Let us now turn to the description of our model. As it has been done in Ref.[10] , we realize the breaking of SO(10) to $SU(3)_c \times U(1)_y \times SU(2)_R \times SU(2)_L = G$ through vacuum expectation values (vev) of two Higgs fields in the representation $\underline{210}$ (see also Ref.[11]). The corresponding superpotential has the form

$$W = M_1 \underline{210}^{12} + \lambda_1 \underline{210}^{13} + \lambda_2 \underline{210}^2 \cdot \underline{210}' + \lambda_3 \varepsilon \underline{210}^2 \cdot \underline{210}' + \lambda_4 u (\underline{210}^2 - M_2^2) , \qquad (1)$$

where M_1 , M_2 are of the same order as the masses of the grand unification, M_x , u are the singlet fields and the last term is formed by means of totally antisymmetric tensor of tenth rank ε .

The representation $\underline{210}$ has the following decomposition under the group $SU(4) \times SU(2)_R \times SU(2)_L$

$$\underline{210} = (6,2,2) + (10,2,2) + (\overline{10},2,2) + (15,1,1) + (15,1,3) + (15,3,1) + (1,1,1) . \qquad (2)$$

When the (1,1,1) component of the field $\underline{210}$ and the (15, 1, 1) component of the field $\underline{210}'$ obtain vev of M_x order, the SO(10) symmetry is broken up to the subgroup G . All the fields from $\underline{210}$ and $\underline{210}'$, except for those connected with the breaking of SO(10), acquiring superlarge masses in accordance with the survival hypothesis for the Higgs fields [12]. The following step is the breaking of the supersymmetry and residual symmetry to the standard one $SU(3)_c \times SU(2)_L \times U(1)_y = G_0$. In Ref. [10] is shown that the supersymmetry and $SU(3)_c \times U(1)_{B-L} \times SU(2)_R \times SU(2)_L$ symmetry can be broken by only one scale parameter $-\mu$, it being assumed, that $M_W \leq \mu \ll M_x$. It allows to obtain the correct scheme of SO(10) breaking in a natural way [10] . The corresponding superpotential reads

$$W = \alpha x (\overline{\underline{126}} \cdot \underline{126} - \mu^2) + \beta y \overline{\underline{126}} \cdot \underline{126} + \gamma z^2 x + M_2 z t + M_3 \overline{\underline{126}} \cdot \underline{126} + \lambda_5 \overline{\underline{126}} \cdot \underline{126} \cdot \underline{210} + \lambda_5' \overline{\underline{126}} \cdot \underline{126} \cdot \underline{210}' , \qquad (3)$$

where x, y, z, t are singlet superfields.

It is not difficult to see that the supersymmetry breaking is due to the vev of the F-components of x and y fields. If x and y fields are substituted by

$$x' = \frac{\alpha x + \beta y}{\sqrt{\alpha^2+\beta^2}} ; \qquad y' = \frac{\alpha y - \beta x}{\sqrt{\alpha^2+\beta^2}} \tag{4}$$

then only the vev of F components of the y' field differ from zero,

$$\langle F_{x'} \rangle = 0 , \quad \langle F_{y'} \rangle = \frac{\alpha\beta\mu^2}{\sqrt{\alpha^2+\beta^2}} . \tag{5}$$

The fermion component of y' is a Goldstone fermion, and the vev of $\langle y' \rangle$ is not fixed.

The breaking of intermediate G symmetry is due to the nonzero vev of neutral colourless component of the field $\underline{126}$ - - the singlet G_0 :

$$\langle 126 \rangle = \langle \overline{126} \rangle = \frac{\alpha\mu}{\sqrt{\alpha^2+\beta^2}} . \tag{6}$$

In result, the intermediate symmetry is broken to $SU(3)_c \times SU(2)_L \times U(1)_y$, and at the same time the supersymmetry is broken. The breaking of the electroweak subgroup must come forth after the account of quantum corrections.

It is easy to see that with the y' field interacts only z and on the tree level the mass splitting for the superpartners occurs only for this field. For the other superfields the mass splitting between the superpartners will occur only after the account of quantum corrections. In order to obtain the mass splitting for the supermultiplets of ordinary particles, one must arrange their effective interaction with the superfield y' . For this purpose the following term has been inserted into the superpotential:

$$\lambda_6 \cdot \underline{210}^2 z . \tag{7}$$

Let us first consider diagrams connected with the masses of the quark and lepton superpartners. It is easy to see that the masses of scalar partners of fermions appear only in the third loop. The superdiagram in Fig.1 with one gauge supermultiplet exchange, makes a zero contribution. It is actually clear that the gauge field in this diagram must be neutral. But even in this case, due to the fact that the representation $\underline{210}$ is self-conjugate, contributions of fields having opposite U(1) charges ($U(1)_{B-L}$, $U(1)_y$), cancel out each other.

The nonzero contribution for the fermion superpartner masses we obtain from the superdiagrams shown in Fig.2 . Likewise, the gauge boson superpartners obtain diagonal masses due to two-loop superdiagrams shown in Fig.3 .

Contribution to the Higgs field mass in the representation $\underline{10}$, which is connected with the breaking of the electroweak group, give the same superdiagrams shown in Fig.2, where only the external lines - the 16-plets of SO(10) are to be changed for 10-plets. In connection with this the following important circumstance must be pointed out. As the doublets in the 10--plet do not interact with the gauge superfields of the Pati--Salam group SU(4), when along the inner loop in the superdiagrams in Fig.2 passes the (15, 1, 1) component of the superfield $\underline{210}$, we shall get a zero contribution to the mass of the Higgs field. In the same case, the contribution to the quark and lepton superpartner masses is other than zero.

When estimating the superdiagrams in Fig.2, it is necessary to take the following into consideration: the dimension of diagrams is $[m^2]$, from the vacuum expectation value of the F component results $[m^4]$, consequently, there must be also $[m^2]$ in the denominator. A concrete calculation shows that in the denominator there always arises the square of the mass of the most heavy particle which passes in the diagram's inner lines. This actually results from the fact that the infrared divergences, which are present separately in each diagram, cancel out each other in sum.

The further calculations are carried out in assumption that M_c, $M_z \ll M_{210}$, where M_c is the mass of the component (15,1,1) of the representation $\underline{210}$, and M_{210} is the smallest mass of the remaining components of the representation $\underline{210}$. This condition is not a hierarchic one: for our purposes a difference of 3-4 times between these quantities is enough.

We shall consider two possibilities which give different results for the masses of the quark and lepton superpartners.

At first assume, that $M_c \ll M_z$ (again, the smallness means a several times of difference between these quantities). In such case the superdiagrams in Fig.2 approximately equally contribute to the masses of the quark and the lepton superpartners

$$m^2_{\tilde{q},\tilde{\ell}} \simeq \frac{\alpha^2(M_c)}{(4\pi)^4} \frac{\lambda_6^2 \gamma^2 \beta^2}{\alpha^2+\beta^2} \frac{|F_y|^2}{M_z^2}, \qquad (8)$$

where $\alpha(M_c)$ is the gauge coupling constant.

Now let us consider the second possibility which is the reverse of the first one: $M_z \ll M_c$. In this case we must take the mass splitting in the multiplet (15,1,1) into account: at breaking of $SU(4)_c \times SU(2)_R \times SU(2)_L$ to G by the vev of the field

$\underline{210}$, there appear masses M_8, M_1 and M_3 for the octet, singlet and triplet of $SU(3)_c$, respectively, which are contained in that representation. We shall consider, that all of them are of the order of the grand unification mass M_x . With regard to this, our condition must read: $\min(M_8, M_3, M_1)$ M_z. In this case the diagrams in Fig.2 make the following contribution to masses of the lepton and quark superpartners:

$$m^2_{\tilde{\ell}} \simeq \frac{\alpha^2(M_c)}{(4\pi)^4} \frac{\lambda_6^2 \gamma^2 \beta^2}{\alpha^2+\beta^2} |F_{y'}|^2 \left(\frac{1}{5}\frac{1}{M_3^2} + \frac{8}{15}\frac{1}{M_{3,8}^2} + \frac{4}{15}\frac{1}{M_{3,1}^2}\right), \qquad (9)$$

$$m^2_{\tilde{q}} \simeq \frac{\alpha^2(M_c)}{(4\pi)^4} \frac{\lambda_6^2 \gamma^2 \beta^2}{\alpha^2+\beta^2} |F_{y'}|^2 \left(\frac{1}{5}\frac{1}{M_3^2} + \frac{8}{45}\frac{1}{M_{3,8}^2} + \frac{4}{45}\frac{1}{M_{3,1}^2} + \frac{8}{15}\frac{1}{M_8^2}\right)$$

where $M_{3,8} = \max(M_3, M_8)$, $M_{3,1} = \max(M_3, M_1)$. When deriving the formulae (9), it was assumed that M_3, M_8, M_1 differ from each other at least for several times, but the formulae are valid also at $M_3 = M_1 = M_8$. Consequently, one can assume that these formulae work well in the whole variation range of M_3, M_1, $M_8 \sim M_x$.

One can see that in contrast to the first case, here the contributions to the masses of the quark and lepton superpartners can be different.

To the masses of the quark and lepton superpartners also contribute the diagrams in Fig.4 [9] on the vertex of which stand Yukawa coupling constants $g_{i,j}$ $\underline{16}_i$ $\underline{10}$ $\underline{16}_j$; (i,j = 1, 2,3). The cross symbol indicates the mass insertion. This contribution by about 15% changes the mass square of the third-generation fermion superpartners and leaves the masses of the superpartners of fermions of the remaining generations practically unchanged. Besides, the fermion superpartners take an additional contribution into their masses due to the same

Yukawa interaction, when the Higgs field 10 receives vev which breaks the electroweak group $SU(2)_L \times U(1)_y$. This contribution is considerable again for only the third generation. At last, the superpartners gain masses due to the same Higgs-field vev from the so-called D-term: this contributes to masses in the region of $(-0.3 + 0.7)\, M_W^2$ [13].

If assumed, that the fermion superpartners must have masses of M_W order, then for reasonable coupling constants the scale parameter μ, responsible for the breaking of the supersymmetry and intermediate symmetry, must be of the order of $10^{11} - 10^{13}$ GeV.

Now let us calculate the contribution of superdiagrams in Fig.2 (with substitution of 16 by 10) to the mass of the Higgs field 10, assuming as before, that $M_c, M_z \ll M_{210}$. Then one obtains the following contribution for the mass square of $SU(2)_L$ doublets contained in 10:

$$m^{02}_{H_{1,2}} = \frac{\alpha^2(M_{210})}{(4\pi)^4}\,\frac{\lambda_6^2\beta^2\gamma^2}{\alpha^2+\beta^2}\,\frac{|F_{y'}|^2}{M^2_{210}} \qquad (10)$$

The contribution of the diagrams in Fig.5 must also be taken into account, which comes from the interaction with the 16-plet. Then one will obtain the following expression for the mass square of the Higgs field:

$$m^2_{H_{1,2}} = m^2_{H^0_{1,2}} - \frac{g^2_{33}}{\pi^2} m^2_{\tilde f} \ln \frac{M_x}{M_{\tilde q,\tilde \ell}}, \qquad (11)$$
$$m^2_{\tilde f} = \frac{3}{4} m^2_{\tilde q} + \frac{1}{4} m^2_{\tilde \ell},$$

where g_{33} is the constant of the interaction of the third-generation fermions with the Higgs field, M_x is the integrals cut-off parameter which must be of the grand unification mass order.

Taking into account that $M_{210} \gg M_z, M_c$, one obtains that $m_H^{02} \ll m_f^2$, and at sufficient, but not very large g_{33}, m_H^2 can be negative: taking into consideration that g_{33} at the t-quark mass of 40 GeV is approximately equal to 1/4, a twice difference between M_{210} and M_z, M_c is sufficient for the negativeness of m_H^2. And what is more, we shall further ignore the first term in the expression of m_H^2 in (11) as against the second term. The negativeness of m_H^2 will lead to spontaneous breaking of the electroweak subgroup. Let us pass to a more detailed study of the Higgs field potential connected with the breaking of $SU(2)_L \times U(1)_y$.

In the beginning note, that to the superpotential must be added two terms

$$\lambda_7\, \underline{10}\ \underline{126}\ \underline{210} + rA\, \underline{10}\ \underline{10}, \qquad (12)$$

where A is the singlet field.

The first term gives natural splitting between different components of the Higgs field by the 10-plets of $SU(3)_c$ and doublets of $SU(2)_L$ (triplet-doublet splitting) [14]: the triplets get superlarge masses of the M_x order, and the doublets remain massless on that level. The same term gives mass to one of the doublets of the order of

$$m_1 = \frac{\alpha^2}{\alpha^2+\beta^2}\,\frac{\lambda_7^2\mu^2}{M_x} \qquad (13)$$

which can also be of the M_W oreder for the corresponding choice of parameters (e.g., $\alpha \ll \beta$) [10]. The second term in (12) provides the presence of a quartic term in the Higgs-field potential.

With regard to the aforesaid, the mass term of two $SU(2)_L$--doublets of the Higgs field H_1 and H_2 contained in 10 has the form

$$m_{H_1}^2 = m_1^2 - m_{\tilde f}^2 \frac{g_{33}^2}{\pi^2} \ln \frac{M_X}{M_{\tilde q,\tilde \ell}} , \qquad (14)$$

$$m_{H_2}^2 = - m_{\tilde f}^2 \frac{g_{33}^2}{\pi^2} \ln \frac{M_X}{M_{\tilde q,\tilde \ell}} ,$$

where we ignored m_H^{02} as against $\frac{g_{33}^2}{\pi^2} m_{\tilde f}^2 \ln \frac{M_X}{M_{\tilde q,\tilde \ell}}$. The quaternary terms in the potential have the following form:

$$V_{(4)} = \frac{1}{8} g_1^2 (H_1^+ H_1 - H_2^+ H_2)^2 + \frac{1}{2} g_2^2 [H_1^+ \vec\tau H_1 + H_2^+ \vec\tau H_2]^2 + \tau^2 |H_1^+ H_2|^2 , \qquad (15)$$

where g_1, g_2 are the gauge coupling constants of groups $U(1)_y$ and $SU(2)_L$, respectively. In the potential (15) there is no term connected with the D-term of the $SU(2)_R$ gauge field - it turns into zero from the condition of minimum over the vacuum expectation values $\langle 126 \rangle$, $\langle \overline{126} \rangle$, when their difference is of the M_W order.

The potential (14,15) has been considered in many works, in particular, in Ref.[9]. Unlike Ref.[9] , in (14) there is no initial mass term for $m_{H_2}^2$. This, and also the circumstance that in our case due to SO(10)-symmetry all the fermions of the same generation enter the same irreducible representation 16 , allow to make more definite predictions.

Minimizing the potential (14), (15), we shall obtain the following expression for the vacuum expectation values v_1 and v_2 of the fields H_1 and H_2 :

$$v_1^2 + v_2^2 = v^2 = - \frac{m_{H_1}^2 + m_{H_2}^2}{\tau^2} ,$$

$$v_1^2 - v_2^2 = \frac{m_{H_1}^2 - m_{H_2}^2}{\frac{1}{2}\bar g^2 - \tau^2} , \qquad (16)$$

where $\bar g^2 = g_1^2 + g_2^2$.

The b and t-quark masses are expressed through v_1 and v_2 in the following way:

$$m_t = g_{33} v_1 , \qquad m_b = g_{33} v_2 \qquad (17)$$

From (14)-(17) it is easy to obtain the following relations:

$$\tau^2 v^2 = 2a \frac{m_t^2 + m_b^2}{v^2} m_{\tilde f}^2 - m_1^2 ,$$

$$v^2 \frac{m_t^2 - m_b^2}{m_t^2 + m_b^2} = \frac{m_1^2}{\frac{1}{2}\bar g^2 - \tau^2} \qquad (18)$$

where

$$a = \frac{1}{\pi^2} \ln \frac{M_X}{M_{\tilde q,\tilde \ell}} \approx 3 .$$

Finally, from (18) one obtains the following inequality:

$$\frac{1}{4} \frac{\bar g^2 v^4}{a m_{\tilde f}^2} - m_b^2 > m_t^2 > \frac{1}{4} \frac{\bar g^2 v^2}{a m_{\tilde f}^2} - 2 m_b^2 . \qquad (19)$$

In the expression (19) one can ignore the b-quark mass as against that of the t-quark. In result one obtains the following final relation connecting the t-quark mass and $m_{\tilde f}$:

$$m_{\tilde f} = 160 \left[\frac{40}{m_t[\text{GeV}]} \right] \text{GeV} . \qquad (20)$$

If assumed that the t-quark mass is 40 GeV, then one will obtain $m_{\tilde f}$ = 160 GeV. In case when the formula (8) takes place ($M_Z \gg M_c$), one has $m_{\tilde q} = m_{\tilde \ell}$ = 160 GeV. With regard to other terms contributing to the masses of the fermion superpartners, one can say, that these masses must be in the range of 150--180 GeV. And if the superpartner masses are determined by the formula (9) ($M_z \ll M_c$) and $m_{\tilde q} \neq m_{\tilde l}$, the following restrictions only take place: $m_{\tilde q} \leqslant 180$ GeV, $m_{\tilde l} \leqslant 329$ GeV. There is a stronger restriction to the minimal one from the values $m_{\tilde l}$ and $m_{\tilde q}$.

$$\min(m_{\tilde \ell}, m_{\tilde q}) \leqslant 160\,\mathrm{GeV}\left(\frac{40}{m_t(\mathrm{GeV})}\right), \tag{21}$$

Now let us consider the appearance of diagonal masses of the gauge -boson superpartners. As already mentioned, these masses appear due to the superdiagrams in Fig.3 . For diagonal masses of the superpartners of gluon, W boson and B boson the following expressions are obtained:

$$\begin{aligned} m_{\tilde g \tilde g} &\simeq \frac{\alpha_3}{12\pi}\,\frac{\lambda_6^2\,\gamma\beta}{\sqrt{\alpha^2+\beta^2}}\,\frac{F_{y'}}{M_z}, \\ m_{\tilde W \tilde W} &\simeq \frac{\alpha_2}{12\pi}\,\frac{\lambda_6^2\,\gamma\beta}{\sqrt{\alpha^2+\beta^2}}\,\frac{F_{y'}}{M_{210}}, \\ m_{\tilde B \tilde B} &\simeq \frac{5}{3}\,\frac{\alpha_1}{12\pi}\,\frac{\lambda_6^2\,\gamma\beta}{\sqrt{\alpha^2+\beta^2}}\,\frac{F_{y'}}{M_z}, \end{aligned} \tag{22}$$

where we restricted ourselves to the case $M_z \gg M_c$ for simplicity. For the complete analysis of the mass of the gauge-particles superpartners, it is necessary to take their mixing with the superpartners of the Higgs fields into consideration [9] , but we shall not do it in detail here. We shall only point out the following circumstance. From the eqs.(22) follows the following relation:

$$\frac{m_{\tilde W \tilde W}}{m_{\tilde g \tilde g}} = \frac{\alpha_2}{\alpha_3}\,\frac{M_z}{M_{210}}, \tag{23}$$

where according to our assumption $M_z < M_{210}$. The formula (23) differs from the result of the supersymmetric SU(5)-model, where the relation $m_{\tilde W \tilde W}/m_{\tilde g \tilde g} = \frac{\alpha_2}{\alpha_3}$ is usually obtained.

The our obtained relation (23) in a certain sense is more acceptable for the following reason. The fact is, that in the SU(5) model the relation $\frac{m_{\tilde W \tilde W}}{m_{\tilde g \tilde g}} = \frac{\alpha_2}{\alpha_3}$ together with the restriction to the mass of gluino $m_{gg} > 1$ GeV [15,16] leads to restriction to the diagonal mass of W bosino: $m_{\tilde W \tilde W} > 300$ MeV . In result the predicted lifetime of proton is on the verge of contradiction with the experiment (if the contribution to the amplitude of proton decay make fifth-order diagrams with W-bosino exchange [17,18]). In our case the corresponding restriction on $m_{\tilde W \tilde W}$ has the form of $m_{\tilde W \tilde W} > \frac{M_z}{M_{210}} \cdot 300$ MeV, i.e. the diagonal mass of W bosino can be less than 300 MeV, which provides a more acceptable value for the proton lifetime.

Other phenomenological aspects of our model related with the mass spectrum and the modes of decays of particles appearing in the model, will be considered in the paper to follow.

Thus, we propose an SO(10) model of superunification, where the supersymmetry is broken together with the intermediate one $SU(3)_c \times U(1)_y \times SU(2)_L \times SU(2)_R$. The lepton and quark superpartners masses appear after the account of the quantum corrections. The presence of the Pati-Salam subgroup SU(4) in SO(10) allows to realize the radiative breaking of the electroweak subgroup. An interesting relation is obtained between the t--quark mass and those of the quark and lepton superpartners. From the point of view of agreement with the proton decay experiments the obtained relation between the diagonal masses of gluino and W boson is more acceptable than the corresponding relation in the SU(5) model.

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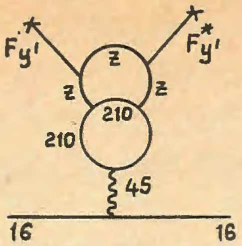

Fig.1. A superdiagram with an exchange of one gauge superfield which makes a zero contribution to the masses of fermion superpartners.

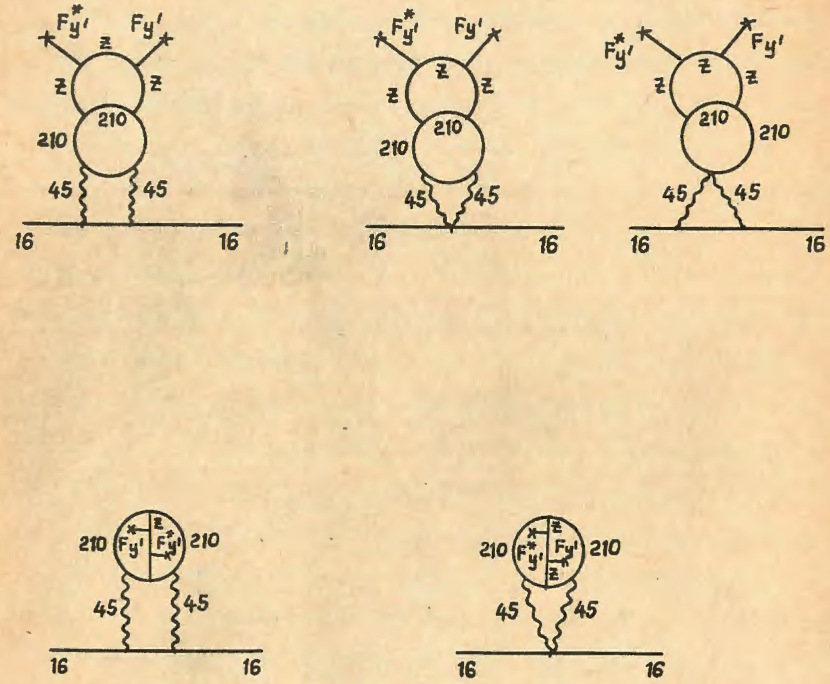

Fig.2 Three-loop superdiagrams making the main contribution to the masses of fermion superpartners.

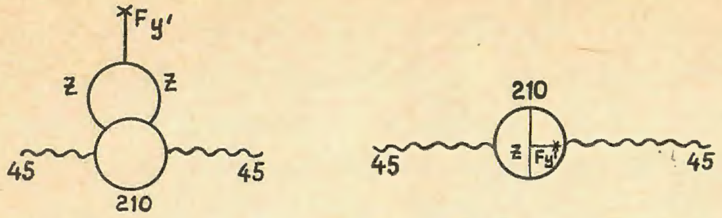

Fig.3 Superdiagrams giving the diagonal mass of the gauge-field superpartners.

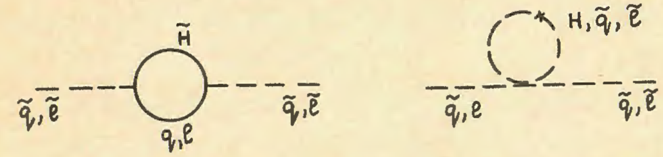

Fig.4 Diagrams making an additional contribution to the masses of the fermion superpartners.

Fig.5 Diagrams making a negative contribution to the mass square of the Higgs fields.

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