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GRAND UNIFICATION AND THE WEINBERG-SALAM MODEL

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Гранд-объединение и модель Вайнберга-Салама

Показано, что в E_8-теории гранд-объединения существует возможность воспроизвести модель Вайнберга-Салама. При этом предсказывается неперенормированное значение $\sin^2\theta_W = 0{,}3$.

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Grand Unification and the Weinberg-Salam Model

It is shown that there is a possibility of reproducing the Weinberg-Salam model in the framework of E_8-scheme of grand unification. The unrenormalized value of $\sin^2\theta_W$ is predicted to be 0.3.

The Investigation has been performed at the Laboratory of Theoretical Physics.

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The purpose of the present note is to draw attention to the possibility of replicating the Weinberg-Salam model with the fixed symmetric value of $\sin^2\theta_W$ =0.3 within the framework of E_8-theory of grand unification.

The agreement of all the available experimental data with the predictions of the Weinberg-Salam theory with $\sin^2\theta_W$ =0.23 is so impressive that it would be much surprising, if there were no some theoretical principle fixing this value. One of the possibilities here comes from the idea of grand unification of strong, weak and electromagnetic interactions. A grand-group G which lies in the base of such a gauge theories describes the quark-lepton symmetry and contains the gauge groups of strong, weak, and electromagnetic interactions. The pattern of embedding of these groups into G fixes the value of $\sin^2\theta_{W_0}$. This symmetric value corresponds to the range of (super-large) momenta, where the breakdown of the initial grand-symmetry may be neglected, and to obtain the value of $\sin^2\theta_W$ at the present energies the renormalization must be carried out. In the known SU(5)-, SO(10) - and E_6-theories [1] $\sin^2\theta_{W_0}$= =3/8 and takes the necessary value after renormalization. However, in these schemes the reducible representation of the grand-group are used to embrace all the fundamental fermions that seems unsatisfactory. The most consistent in this view are exceptional E_7 - and E_8-models [2,3]. Let us first consider the more economic E_7-scheme. The fundamental fermions and the gauge fields in the E_7-theory are contained in $\underline{56}$- and $\underline{133}$-plets, respectively. Under the subgroup $SU(6)_{flavor} \times SU^c(3)$ these representations decompose as follows:

$$\underline{56} = (20.1^c) + (6.3^c) + (\bar{6}.\bar{3}^c)$$
$$\underline{133} = (35.1^c) + (\overline{15}.3^c) + (15.\bar{3}^c) + (1.8^c) \qquad (1)$$

and $\sin^2\theta_W$ takes a too big value 3/4 (2/3 after renormalization [4]) if the standard definition of the electric charge

$Q = \mathrm{diag}\ (2/3,\ -1/3,\ -1/3,\ 2/3,\ -1/3,\ -1/3)$ is assumed. However, there is yet another possible definition in the E_7-theory[2]

$$Q = \mathrm{diag}\,(2/3\,,\,-1/3\,,\,2/3\,,2/3\,,-1/3\,,\,-4/3)\,. \qquad (2)$$

Our first observation is that definition (2) leads to the value of $\sin^2\theta_W = 0.3$ (2/9 after renormalization). Besides, contrary to the previous case, the charged leptonic singlets of the standard-defined group $SU(2)_W$ of weak interactions appears, and this fact gives a possibility to satisfy the Weinberg-Salam prescription for e^-_R, μ^-_R.

Unfortunately, there are no quark $SU(2)_W$ -singlets with the electric charge -1/3 in the theory with Q defined as in Eq. (2). This means, that d_R is to be placed into doublet contrary to the experimental data[5]. Our main note now is that this difficulty disappears in E_8-theory. Indeed, in the E_8-scheme the fermions as well as the gauge fields transform as $\underline{248}$. (This gives a possibility of natural supersymmetric formulation of the theory). The $\underline{248}$-plet decomposition under the maximal subgroup $E_7 \times SU(2)$ is

$$\underline{248} = (56.2) + (133.1) + (1.3). \qquad (3)$$

Preserving the standard definition of $SU(2)_W \subset SU(6) \subset E_7 \subset E_8$ and the definition (2) of electric charge operator we find that $\sin^2\theta_{W_0} = 0.3$. It is evident from Eqs. (1), (3) that colour-triplet quarks are contained in the following representation of the flavour group $SU(6) \times SU(2)$

$$(6.2) + (\overline{15}.1)$$

and since there are two $SU(2)_W$-singlets with electric charge -1/3 in $\overline{15}$-plet, the above-mentioned difficulty with d_R -quark is absent. Hence, in the framework of the E_8-theory the quantum numbers of the known fermions may be assigned in full agreement with the Weinberg-Salam prescription, and the value of $\sin^2\theta_{W_0}$ is close to the one favored by experiment. The renormalized value of $\sin^2\theta_W$ here depends on the details of symmetry breakdown. Namely, as there are 27 quark flavors plus 8 quarks with the quantum numbers of gluons (see in this connection ref.[6]), some of them have to acquire super-large masses to provide the asymptotic freedom of QCD, while the value of $\sin^2\theta_W$ depends on what quarks in the theory remain light.

The E_8-group is an exceptional group of maximal rank ($E_8 \supset E_7 \supset E_6 \supset F_4 \supset G_2$) and realizes in this sense an extreme possibility of grand-symmetry. But in spite of its redundancy conditioned by the great number of fundamental fermionic fields the E_8-theory deserves the thorough investigation owing to its above-stated ability to reproduce the Weinberg-Salam model with reasonable $\sin^2\theta_{W_0}$.

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