HIERARCHY OF MASSES FOR FERMION GENERATIONS

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Very small ratios of fermion masses for various generations: $m_1/m_2 \sim 10^{-2}$, $m_1/m_3 \sim 10^{-3}$—10^{-4}, — require to use enormous differences (10^4—10^5) between coupling constants of all contemporary theories explaining the problem. This makes the explanations rather artificial.

At the same time the tiny numbers are of a normal order for ratios of subsequent terms of any perturbation theory (PT) with the factor $g^2/(4\pi)^2 \sim 10^{-2}$, $g^2 \sim 1$. Some unperturbative scenario of phenomena can be developed to present PT as a natural explanation for the hierarchy of fermion generations /1/. Simultaneously, the same reason explains also main correlation between elements of the quark mixing matrix (KM-matrix).

The appropriate conditions may appear in the system differing from the initial Lagrangian of the Standard Model (SM) only in one respect: the f-massless fermion (u,d) generations interact with the new neutral vector field Z′

$$L' = \sum_{i=1}^{f} \sum_{m=u,d} \{G_i^m \bar{\Psi}_{iL}^m \gamma_\mu \Psi_{iL}^m + \tilde{G}_i^m \bar{\Psi}_{iR}^m \gamma_\mu \Psi_{iR}^m\} Z'_\mu .$$

There are no fundamental scalars at all.

The main point of the scheme is the absence of Z′ gauge invariances, which are violated by Z′-SM gauge bosons triangle anomalies. The theory becomes nonrenormalizable. It is necessary to assume that small-distance properties of Z′ provide the low-energy scheme with the ultraviolet cut-off M (the composite nature of Z′, for example).

These properties permit to model the situation with the following consequences.

1. One of the fermion generations (f) produces a condensate with a large density: $\langle \bar{\Psi}_f \Psi_f \rangle \sim M^3 \neq 0$, and acquires a mass larger than the cut-off M.
2. The gauge noninvariant boson Z′ also becomes massive.
3. The generations i=1,2...f—1 obtain masses and generate the mixing matrix due to i⇄f transitions into the condensate.

The i-masses are provided with the subsequent PT contributions of fermion — Z′-interactions. Only the twooloop PT approximation of the mass matrix gives all the masses not equal to zero in case of three generations (i=1,2,3; f=4). The large difference between masses is related with PT factors $[g^2/(4\pi)^2]^n$. The most heavy generation is really the first one from this point of view.

The PT factors and $SU_L(2)$ invariance explain also the hierarchy of the KM-elements, producing the KM matrix which can be easily matched with the experimental one.

If the Z′-particle arises with the large mass: $M_{Z'} \sim M > 1$ TeV, we deal with a practical scheme, which could be similar to SM, but without the Higgs scalars. However it is impossible to have the neutral transitions between heavy generations $2 \rightleftarrows 3$ as small as between the light ones $1 \rightleftarrows 2$ ($1 \rightleftarrows 3$). All these transitions are induced by Z′. This means that the $<B_s|\bar{B}_s>$ matrix element exceeds $<B_d|\bar{B}_d>$ one by 10^3—10^4 times.

The attempt to apply the scheme to leptons shows that it is rather difficult to obtain massive neutrinos and their mixing. All neutrinos remain massless.

REFERENCE

1. *Dyatlov I. T.* Preprint LNPI-1572. Leningrad. 1990. 30 p. Yad. Phys. 1990. N 7.