Family Replicated Gauge Group Models

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Abstract

Recently it was shown by N.Arkani-Hamed, A.G.Cohen, H.Georgi et al. that family replicated gauge groups (FRGG) of the type $SU(n)^N \times SU(m)^N$ provide new directions for research in high energy physics and quantum field theory. In their model of Deconstruction of space–time, they tried to construct renormalisable asymptotically free four dimensional gauge theories which dynamically generate a fifth dimension (maybe more). Such theories naturally lead to electroweak symmetry breaking, relying neither on supersymmetry nor on strong dynamics at the TeV scale. The new TeV physics is perturbative and radiative corrections to the Higgs mass are finite. The new Higgs scalar is an extended object — pseudo–Nambu–Goldstone boson — and a novel Higgs potential emerges naturally requiring a second light SU(2) doublet scalar. The extension of the Standard Model (SM) with an FRGG–symmetry of the type $G = (SMG)^3 \equiv [SU(3)_{c(color)}]^3 \times [SU(2)_{L(left)}]^3 \times [U(1)_{Y(hypercharge)}]^3$ was first suggested by D.L.Bennett, H.B.Nielsen and I.Picek (1988) and developed by C.D.Froggatt and H.B.Nielsen (*Origin of Symmetries*, 1991). This Anti–grand unification theory (AGUT) assumes that at a scale $\sim 10^{18}$ GeV there is a spontaneous breakdown of the FRGG–symmetry to its diagonal subgroup G_{diag}, which was identified with the usual (low–energy) Standard Model group (SMG). The generalized gauge group $(SMG)^3 \times U(1)_{f(flavor)}$ was suggested by the fitting of the SM fermion masses. But then H.B.Nielsen and Y.Takanishi considered the further extended FRGG–symmetry $G_{ext} = (SMG \times U(1)_{B-L})^3$ taking into account the right–handed neutrinos. The FRGG G_{ext} was used by C.D.Froggatt, H.B.Nielsen and Y.Takanishi to fit the SM fermion masses and mixing angles and to describe all modern neutrino experiments using only 5 free parameters — five VEVs of the Higgs fields which break the FRGG–symmetry to the SM. This typical fit is very encouraging. L.V.Laperashvili, H.B.Nielsen and D.A.Ryzhikh have shown that the Abelian monopoles (existing also in non–Abelian theories) in the FRGG–model have N^* times smaller magnetic charge than in the SM, where $N^* = N(N+1)/2$. These monopoles can appear at high energies in the FRGG–model and give additional contributions to the beta–functions of the renormalisation group equations for the running fine structure constants $\alpha_i(\mu)$ (i=1,2,3 corresponds to the U(1), SU(2) and SU(3) gauge groups of the SM). Taking into account these monopole contributions, it was shown that, in contrast to the case of AGUT, there exists the possibility of unifying all the gauge couplings if the FRGG–breakdown occurs at the scale $\sim 10^{14}$ GeV. In this talk we shall discuss all the above topics and also briefly consider the possibility of $[SU(5)]^3$ or $[SO(10)]^3$ unification at the GUT–scale $\sim 10^{18}$ GeV.