

SU(5) grand unification in a transfinite form

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Abstract

The SU(5) grand unification with its $|\text{SU}(5)| = 24$ gauge Bosons is partially reformulated in a transfinite setting. By means of transfinite continuation it is shown that a new version of the theory yields an expectation value $\langle |\text{SU}(5)|_c \rangle = 26 + k$ instead of the classical 24. By systematically exploring the non-super symmetric SU(5) scheme and transforming many of its fundamental aspects, it becomes plausible that it is a fundamental theory which could be integrated in various other fundamental theories including the transfinite forms of super strings and M theory.

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1. Introduction

Despite failure to predict the right time scale for protons decay, the non-super symmetric SU(5) grand unification is a highly elegant theory and the seamless fitting of the standard model $\text{SU}(3) \otimes \text{SU}(2) \otimes \text{U}(1)$ into its fundamental symmetry group SU(5) makes it extremely difficult to believe that the theory could be entirely wrong [1–3].

In fact, and as we will be arguing in the present short work, the theory is substantially correct, at least in its basic structure. Using the technique of transfinite continuation we will show that SU(5) unification could be given a twist along the lines of E -infinity theory and link it to a family of other similar theories formulated in a fuzzy setting [3–23].

2. The SU(5) grand unification

The standard model of high energy physics is based on a combination of three symmetry groups, the order of which gives us 12 gauge Bosons [3,10,11]

$$|\text{SU}(3) \otimes \text{SU}(2) \otimes \text{U}(1)| = 12$$

By contrast the SU(5) model has double as much, namely [1,2]

$$|\text{SU}(5)| = 24$$

where besides the photon (γ), the $W^\pm$, the Z_0 and the 8 Gluons we have an additional 12 exotic gauge Bosons. Thus while we have 12 flavour and colour forces in the standard model [1–3]

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$$G_\mu^a, W_\mu^\pm, Z_\mu, A_\mu$$

an additional 12 super weak and lepton-quark forces

$$X_\mu^i, Y_\mu^i, \tilde{X}_{i\mu}, \tilde{Y}_{i\mu}$$

are assumed to exist in SU(5).

The anomaly free combination of SU(5) representation is given by $\{\bar{5}\} + \{10\}$ and the relevant multiplets are shown in Fig. 8 of Ref. [3]. The $\{24\}$ of SU(5) under $SU(3)_c \times SU(2)_L \times U(1)$ decomposes as follows [1–3]

$$\{24\} = \{8, 1\} + \{1, 3\} + \{3, 2\} + \{3^*, 2\} + \{1, 1\}$$

To find $|SU(5)|$ from the above we just need to proceed formally as below:

$$|SU(5)| = (8)(1) + (1)(3) + (3)(2) + (3^*)(2) + (1)(1) = 8 + 3 + 6 + 6 + 1 = 24.$$

We will refer to this as the multiplication order which is normally given by $N^2 - 1 = 25 - 1 = 24$. For later use we mention that a second formal way to find our 24 is to write

$$|SU(5)| = [8 + 1 + 1 + 3 + 3 + 2 + 3^* + 2 + 1 + 1] - 1 = [25] - 1 = 24.$$

This is nothing but a trivial way of rewriting $|SU(5)| = N^2 - 1$ as $N^2 = |SU(5)| + 1$ where $[25] = N^2$. The value N^2 will be labelled the additive order.

By choosing SU(5), the couplings of the electroweak unifications are fixed [1,2]

$$g^1 = \sqrt{\frac{3}{5}} g_{SU(5)}$$

and because

$$g_{SU(5)} = g$$

and

$$\tan \theta_w \equiv g^1 / g$$

one finds that

$$\tan \theta_w = \sqrt{\frac{3}{5}}$$

Therefore the Weinberg mixing angle is given in this case by

$$\sin^2 \theta_w = 3/8$$

A further prediction of SU(5) grand unification is that

$$\alpha_1(M_x) = \alpha_2(M_x) = \alpha_3(M_x) = \alpha_u$$

where $M_x \simeq 10^{15}$ GeV is the unification energy and $\alpha_u \simeq 1/50$ is the unification coupling. It should be noted however that extrapolation of measured values at LEP and SLC shows a lack of unification of gauge coupling for the standard model, but that averaging based on the centre of gravity of the triangle formed by the three lines of the running coupling gives $\alpha_u \simeq 1/42$, rather than $\alpha_u \simeq 1/50$.

Interestingly, L. Marek-Crnjac in Slovenia also found that $\alpha_u \simeq 1/42$ while the exact value predicted by E -infinity theory is $\bar{\alpha}_g = 1/\alpha_u = 42.36067977$.

3. Transfinite continuation of SU(5)

At a minimum, fuzzy sets, fuzzy logic and fuzzy geometry have been for decades infiltrating numerous branches of engineering and technology [5–7] and in a relatively lesser measure, also physics [4,8,9]. The concepts of fuzziness come under various names and a particularly important category increasingly used in high energy physics is that connected to fractal statistics and fractal geometry [23].

In particular E -infinity theory used a form of transfinite fuzziness which was utilized to solve numerous problems in quantum mechanics [14] and high energy physics. Thus the notion of a non-integer fractal dimension has been generalized to the extent of talking in precise terms about 0.23606799 particles or 6.1803398977 elementary particles. Translated

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