CERN LIBRARIES, GENEVA

CM-P00061681

Archives

Ref.TH.2408-CERN

CHARGE RENORMALIZATION IN A SUPERSYMMETRIC
YANG-MILLS THEORY

D.R.T. Jones
CERN - Geneva

ABSTRACT

The renormalization group function $\beta(g)$ is found to vanish in the two-loop approximation for a recently derived SU(4) supersymmetric Yang-Mills theory.

Ref. TH.2408
18 October 1977

When supersymmetric Yang-Mills theories were first constructed ^{1),2)}, it was observed that in a class of such models the renormalization group function $\beta(g)$ vanished identically in the one-loop approximation. A particular example of this class consists of a model in which a Yang-Mills multiplet (W_μ, λ) interacts with three matter multiplets (ψ, A, B) with all fields transforming according to the adjoint representation of the gauge group. The two-loop calculation was subsequently performed ³⁾ and it was found that its contribution was non-vanishing for all such models.

Recently Brink, Schwartz and Scherk ⁴⁾, and Gliozzi, Olive and Scherk ⁵⁾ have derived a supersymmetric theory with the same field content as the one mentioned above but with different Yukawa and quartic scalar couplings. The Lagrangian is:

$$\begin{aligned} \mathcal{L} = & -\frac{1}{4} G_{\mu\nu}^a G_{\mu\nu}^a - \frac{1}{2} \bar{\lambda}_K^a \gamma_\mu (\mathcal{D}_\mu \lambda_K)^a \\ & - \frac{1}{2} (\mathcal{D}_\mu A_i)^2 - \frac{1}{2} (\mathcal{D}_\mu B_i)^2 \\ & + \frac{1}{2} g f^{abc} \bar{\lambda}_K^a \left[\alpha_{KL}^j A_j^b + \gamma_5 \beta_{KL}^j B_j^b \right] \lambda_L^c \\ & + \frac{1}{4} g^2 \left[(f^{abc} A_i^b A_j^c)^2 + (f^{abc} B_i^b B_j^c)^2 + 2(f^{abc} A_i^b B_j^c)^2 \right] \end{aligned}$$

Here $K: (1 \dots 4)$, $i, j: (1 \dots 3)$ and $a, b, c: [1 \dots N]$. The f^{abc} are the structure constants of the gauge group G . The λ_K^a are Majorana fermions.

The matrices α_i, β_i are defined by the relations

$$\begin{aligned} \{\alpha_i, \alpha_j\} &= \{\beta_i, \beta_j\} = -2\delta_{ij} \\ [\alpha_i, \beta_j] &= 0 \end{aligned}$$

The model has an $SU(4)$ supersymmetry and as a consequence the Yukawa and scalar couplings have a more symmetric appearance.

We write

$$\beta(g) = \frac{A g^3}{16\pi^2} + \frac{B g^5}{(16\pi^2)^2}$$

The calculation of A is identical to that for the models in Ref. 3), so that we find $A=0$.

The contribution to B from pure gauge, gauge-fermion and gauge-scalar interactions can also be trivially calculated from Eqs. (15) and (16) of Ref. 3) giving a total of

$$12[C_2(G)]^2$$

The only change to the calculation [assuming that as in Ref. 3) we obtain β from the W -ghost vertex] arises from the graphs contributing to Z_3 which contain Yukawa couplings. (The scalar self-couplings do not contribute.) However, using the relation

$$\sum_j \text{Tr}(\alpha^j \alpha^j) = \sum_j \text{Tr}(\beta^j \beta^j) = -12$$

it is easily shown that the effect of the new couplings is to double the Yukawa contribution. Thus from Eq. (18) of Ref. 3) we see that the total Yukawa contribution is

$$-12[C_2(G)]^2$$

so that the total two-loop contribution vanishes for any group G .

This is an interesting result, but it is by no means clear whether or not it will persist in higher orders (and what the significance would be if it did). In addition the model itself is a possible candidate for a unified theory of particle interactions and it is clear that it deserves further investigation.

I would like to thank M. Gell-Mann, B. Zumino and S. Ferrara for drawing the model considered here to my attention, and for conversations.

REFERENCES

- 1) S. Ferrara and B. Zumino, Nuclear Phys. B79, 413 (1974).
- 2) A. Salam and J. Strathdee, Phys. Letters 51B, 353 (1974).
- 3) D.R.T. Jones, Nuclear Phys. B87, 127 (1975).
- 4) L. Brink, J.H. Schwartz and J. Scherk, Nuclear Phys. B121, 77 (1977).
- 5) F. Gliozzi, D. Olive and J. Scherk, Nuclear Phys. B122, 253 (1977).