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Comments on the role of field redefinition on renormalisation of $N = \frac{1}{2}$ supersymmetric pure gauge theory

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Abstract

We study one loop corrections to $N = \frac{1}{2}$ supersymmetric $SU(N) \times U(1)$ pure gauge theory. We calculate divergent contributions of the 1PI graphs that contain the non-anti-commutative parameter C up to one loop corrections. We find that the disagreement between component formalism and superspace formalism is because of the field redefinition in component case. We modify gaugino field redefinition and lagrangian. We show that extra terms of lagrangian have been generated by λ redefinition and are necessary for the renormalisation of the theory. Finally we prove that $N = \frac{1}{2}$ supersymmetric gauge theory is renormalisable up to one loop corrections using standard method of renormalisation.

Keywords: $N = 1/2$ supersymmetric theory; Non-commutative geometry; Renormalisation

1. Introduction

Theories defined on non-anticommutative superspace have been studied extensively during last ten years [1,2]. Superspace in such non-anticommutative theories is a superspace whose fermionic supercoordinates are not anti-commutative. One could construct a field theory in

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non-anticommutative superspace in terms of superfields with the star-product where lagrangian is deformed from the original theory by the non-anticommutative parameters.

Recently some renormalisability aspects of the non-anticommutative field theories have been studied. It has been shown that non-anticommutative field theories are not power-counting renormalisable; however it has been discussed that they could be renormalisable if some additional terms had been added to the lagrangian in order to absorb divergences to all orders [3–8]. The renormalisability of non-anticommutative versions of the Wess–Zumino model has been discussed [3,4], with explicit computations up to two loops [5]. The renormalisability of non-anticommutative gauge theory with $N = \frac{1}{2}$ supersymmetry has been studied in [6,8]. The authors in [6] show that the theory is renormalisable to all orders of perturbation theory. The conditions of the renormalisability of non-anticommutative (NAC) field theories have been studied with explicit computations up to one and two loops [9–16].

The renormalisability of supersymmetric gauge field theories has been discussed in WZ gauge [6,7]. The explicit one loop corrections in component formalism have been done in [9–11]. The authors in [10,11] have claimed the precise form of the lagrangian is not preserved by renormalisation. They have shown by explicit calculation that there are problems with assumption of gauge invariance which is required to rule out some classes of divergent structure in non-anticommutative theory. From their calculation, one can see that even at one loop divergence non-gauge-invariant terms are generated. In order to remove the non-gauge-invariant terms and restore gauge invariance at one loops they introduce a one loop divergent field redefinition in the case of pure $N = \frac{1}{2}$ supersymmetry (i.e. no chiral matter).

On the other hand, the authors in [12,13] have started from superspace formalism and discussed renormalisability and supergauge invariance. They have proved that the field redefinition is not necessary and the original effective action is not only gauge but also supergauge invariant up to one loop corrections. The disagreement between two approaches put a big question mark which approaches we should rely on in $N = \frac{1}{2}$ supersymmetric gauge theory.

In this paper we investigate the renormalisability of $N = \frac{1}{2}$ supersymmetric pure gauge theory at one-loop perturbative corrections in component formalism. We shall show that $N = \frac{1}{2}$ supersymmetric gauge theory is renormalisable in a usual manner without any needs for field redefinition (there is not theoretical justification or interpretation for the field redefinition as mentioned by authors [10]) which leads to the lagrangian change. Therefore we shall prove that two approaches lead to the same conclusion.

The paper is organised as follows: first we briefly review NAC supersymmetric gauge theories and their lagrangian. Then an explicit one-loop calculation of three and four-point functions of the theory in the C-deformed sector is carried out to calculate corrections. We show some anomaly terms appears in the 1PI functions which spoil the renormalisability of theory. Next we introduce extra terms to the original lagrangian in order to renormalise NAC pure gauge supersymmetric theory and calculate corrections which come from these new terms. Finally we discus the source of the extra lagrangian, and show that these new terms have hidden because of the component λ redefinition [1,17], so in order to reproduce them one should reverse gaugino field redefinition.

2. The pure gauge supersymmetric action of NAC gauge theory

The original non-anti-commutative theory defined in superfields appears to require a $U(N)$ gauge group. Here, at first we would like to consider $U(N)$ gauge theory for non-(anti)commuta-