Available online at www.sciencedirect.com
ScienceDirect
Nuclear Physics B 794 (2008) 216–230
NUCLEAR PHYSICS B
www.elsevier.com/locate/nuclphysb

$\mathcal{N} = 2$ quiver gauge model and partial supersymmetry breaking

H. Itoyama [a,b], K. Maruyoshi [a,*], M. Sakaguchi [c]

[a] *Department of Mathematics and Physics, Graduate School of Science, Osaka City University, Japan*
[b] *Osaka City University Advanced Mathematical Institute (OCAMI), 3-3-138 Sugimoto, Sumiyoshi-ku, Osaka 558-8585, Japan*
[c] *Okayama Institute for Quantum Physics, 1-9-1 Kyoyama, Okayama 700-0015, Japan*

Received 27 September 2007; accepted 5 November 2007

Available online 12 November 2007

Abstract

We construct an action of $\mathcal{N} = 2$ affine A_n quiver gauge model having non-canonical kinetic terms and equipped with electric and magnetic FI terms. $\mathcal{N} = 2$ supersymmetry is shown to be broken to $\mathcal{N} = 1$ spontaneously and $\mathcal{N} = 1$ multiplets realized on the vacua are given. We also mention the models with different gauge groups. It is argued that the affine A_1 quiver gauge model provides a dynamical realization to approach the Klebanov–Witten $\mathcal{N} = 1$ fixed point.

PACS: 11.30.Pb; 12.60.Jv

Keywords: Quiver gauge theory; Partial supersymmetry breaking; $N = 2$ supersymmetry

1. Introduction

Supersymmetry has become one of the most remarkable and attractive ideas in theoretical physics. In particular, various investigations beginning with [1,2] have been made on $\mathcal{N} = 2$ supersymmetric Yang–Mills theory in four dimensions, taking advantage of its powerful properties. Furthermore, we can extract the important information of $\mathcal{N} = 1$ super-Yang–Mills theory,

* Corresponding author.
E-mail addresses: itoyama@sci.osaka-cu.ac.jp (H. Itoyama), maruchan@sci.osaka-cu.ac.jp (K. Maruyoshi), makoto_sakaguchi@pref.okayama.jp (M. Sakaguchi).

0550-3213/$ – see front matter
doi:10.1016/j.nuclphysb.2007.11.001

such as the low energy effective superpotential, breaking $\mathcal{N}=2$ supersymmetry to $\mathcal{N}=1$ by a superpotential [2–4].

On the other hand, in view of the fact that superstring theories produce, in some backgrounds, extended supersymmetry in four dimensions and have no adjustable parameter, it is natural to consider spontaneous breaking of the extended supersymmetry so as to obtain more realistic $\mathcal{N}=1$ supersymmetric models. Although it had been argued that, based on the supercharge algebra, rigid $\mathcal{N}=2$ supersymmetry is not spontaneously broken to $\mathcal{N}=1$, a loophole has been first pointed out in [5] by the argument based instead on the supercurrent algebra which has been modified by an additional space–time independent term. In [6] and [7–9], $\mathcal{N}=2$, $U(1)$ and $U(N)$ gauge models with $\mathcal{N}=2$ vector multiplet only have been constructed, establishing this modification of the algebra by introducing magnetic Fayet–Iliopoulos (FI) term. It was shown that the partial breaking of $\mathcal{N}=2$ supersymmetry indeed occurs in such models. (See also [10–12] for related discussions and [13] for supergravity.)

In the $U(N)$ gauge theory which contains only the $\mathcal{N}=2$ vector multiplet, the magnetic FI term which causes the partial breaking can be easily introduced in the harmonic superspace formalism [14] (see [15] for a review) as a constant shift of the auxiliary field [9,16]. In addition, it was shown that partial supersymmetry breaking can occur even in the presence of hypermultiplets in the adjoint representation. However, the addition of hypermultiplets in fundamental representation makes it difficult, as pointed out in [17,18]. In this paper we overcome this difficulty by considering a model with hypermultiplets in bi-fundamental representation, whose matter content is described by a quiver diagram. This model is, therefore, a quiver gauge model. We will show that, in addition to electric FI term, it is possible to introduce a magnetic FI term for any $\mathcal{N}=2$ quiver gauge theory. This statement leads to the conclusion that in generic $\mathcal{N}=2$ quiver gauge theory with these terms, $\mathcal{N}=2$ supersymmetry can be broken to $\mathcal{N}=1$ spontaneously. As an illustration, we will describe this explicitly in a specific model, affine A_1 quiver gauge model, focusing on the Coulomb branch.

This model may seem reminiscent of the one discussed in [19]: a flow, by a mass deformation, from the $\mathcal{N}=2$ affine A_1 theory on the world volume of the D3-branes at $\mathbb{C}^2/\mathbb{Z}_2$ orbifold singularity to $\mathcal{N}=1$ quiver gauge theory on that at conifold singularity. Indeed, we can show that in special points of the Coulomb branch the mass spectrum is the same as that of the theory at the conifold singularity. The remarkable point of our model is that the masses are produced dynamically, and thus we can dynamically approach the theory on conifold, namely conifold geometry.

The organization of this paper is as follows. In Section 2, we construct $\mathcal{N}=2$ affine A_{n-1} quiver gauge model equipped with electric and magnetic FI terms. The necessary condition to introduce the magnetic FI term without breaking $\mathcal{N}=2$ supersymmetry in the action is examined. We also mention the cases of different types of quiver gauge theories. As an illustration, we mainly consider one of the simplest models, affine A_1 quiver gauge model, in the subsequent sections. In Section 3, we derive the scalar potential which is needed in the analysis of the vacua. We show, in Section 4, that $\mathcal{N}=2$ supersymmetry is broken to $\mathcal{N}=1$ spontaneously on the Coulomb branch by observing the mass spectrum and the appearance of the Nambu–Goldstone fermion. As an application of our model, in Section 5, we consider the dynamical realization of $\mathcal{N}=1$ quiver gauge theory on the world volume of the D3-branes at the conifold singularity which has been considered in [19]. The notations on the harmonic superspace used in this paper are collected in Appendix A.