Partial Breaking of $\mathcal{N}=2$ Supersymmetry and Decoupling Limit of Nambu-Goldstone Fermion in $U(N)$ Gauge Model

Osaka City University Kazuhito Fujiwara
E-mail: fujiwara@sci.osaka-cu.ac.jp

The fermionic shift symmetry is a key point of the proof of the Dijkgraaf-Vafa conjecture which assert that non-perturbative quantities in a $\mathcal{N}=1$ supersymmetric gauge theory can be computed by a matrix model . Thanks to this symmetry, effective superpotential is written as $W_{\text{eff}} = \int d^2\chi \mathcal{F}_p$, for some function $\mathcal{F}_p$ which is related to the free energy of the matrix model. The fermionic shift symmetry is due to a free fermion and is expected to come from a second, spontaneously broken supersymmetry. The $U(N)$ gauge model which breaks $\mathcal{N}=2$ supersymmetry to $\mathcal{N}=1$ spontaneously was studied in [1]. The Nambu-Goldstone fermion appears in the overall $U(1)$ part of $U(N)$ gauge group and is coupled to the $SU(N)$ sector because of the fact that the 3rd derivatives of the prepotential $\mathcal{F}$ are non-vanishing .

In [2], We examine a decoupling limit of the Nambu-Goldstone fermion. How can we take such limit with partial breaking of supersymmetry ($\mathcal{N}=2\to1$) in $U(N)$ gauge model? In order to decouple the Nambu-Goldstone fermion, we should make the prepotential $\mathcal{F}$ be a second order polynomial. However the order of the prepotential is greater than or equal to 3 because of the condition for partial breaking of $\mathcal{N}=2$ supersymmetry. This problem can be solved by a large limit of the parameters (e,m,ξ) of the electric and magnetic FI terms. Let us reparametrize

$$(e,\ m,\ \xi) = (\Lambda e',\ \Lambda m',\ \Lambda \xi'), \quad \mathcal{F} = \sum_{k=0}^{n} \mathrm{tr}\frac{g_k}{k!}\Phi^k = \mathrm{tr}\left(g_0\mathbf{1} + g_1\Phi + \frac{g_2}{2}\Phi^2\right) + \frac{1}{\Lambda}\sum_{k=3}^{n}\mathrm{tr}\frac{g'_k}{k!}\Phi^k$$

After taking the limit $\Lambda\to\infty$, the Nambu-Goldstone fermion is decoupled from other fields, while partial breaking of $\mathcal{N}=2$ supersymmetry is realized as before. We get a general $\mathcal{N}=1$ action which include the free fermion. It shows that the fermionic shift symmetry is due to the free Nambu-Goldstone fermion.

References

[1] K. Fujiwara, H. Itoyama and M. Sakaguchi, "Supersymmetric U(N) gauge model and partial breaking of N = 2 supersymmetry," Prog. Theor. Phys. **113** (2005) 429 [arXiv:hep-th/0409060]; "Partial breaking of N = 2 supersymmetry and of gauge symmetry in the U(N) gauge model," Nucl. Phys. B **723** (2005) 33 [arXiv:hep-th/0503113]; "Partial supersymmetry breaking and N = 2 U(N(c)) gauge model with hypermultiplets in harmonic superspace," Nucl. Phys. B **740** (2006) 58 [arXiv:hep-th/0510255].

[2] K. Fujiwara, "Partial breaking of N = 2 supersymmetry and decoupling limit of Nambu-Goldstone fermion in U(N) gauge model," arXiv:hep-th/0609039.