$N = D = 2$ Twisted Super Yang-Mills on a Lattice

Department of Physics, Hokkaido University Kazuhiro NAGATA
E-mail: nagata@particle.sci.hokudai.ac.jp

The main purpose of lattice supersymmetry is to give a constructive formulation of supersymmetry which reveals the non-perturbative aspect of supersymmetric models. We are also strongly motivated by the aspect of fermion regularization, since the lattice formulation of supersymmetry should inevitably contain the information of fermionic structure of spacetime.

It is well known that the main difficulty of lattice supersymmetry comes from the breakdown of Leibniz rule on a lattice, or in a rigid sense, the lattice modification of Leibniz rule. Since the super-invariance of the action is in general up to surface terms which come after the use of Leibniz rule, the lattice modification means that naive descretization does not work. Therefore, in order to make a rigid construction of lattice supersymmetry, we have to take into account the nature of lattice Leibniz rule.

In [1], we construct two dimensional N=2 supersymmetric BF and twisted Wess-Zumino model, based on the formulation of twisted 'mild' non-commutative superfield method. The main advantage of this method is that all the supercharges in the algebra can be exactly realized on the lattice, and as a result, the action is invariant w.r.t. all the supercharges on the lattice. It is also important that the lattice fermions in the above multiplet consist staggered fermions or Dirac-Kahler fermions, which is a direct consequence of the twisted algebra which we start from. In this procedure, the R-symmetry of N=2 turns out to be the internal flavor symmetry of Dirac-Kahler fermion on the lattice, and as a result, the spectrum can be away from the species doubling.

In [2], we extend the above framework to the gauge theory and formulate N=D=2 twisted super Yang-Mills on a lattice. Since the most important ingredient in the lattice gauge theory is the gauge link variable which ensures the gauge covariance of the system, correspondingly all the lattice operators including supercharges should be re-formulated to be compatible with the link nature. In this procedure, the above 'mild' non-commutative supercharges are naturally re-formulated by the gauge covariant fermionic link operators of lattice supersymmetry.

We have also established the manifest gauge covariant method to construct the explicit lattice gauge multiplet as well as the lattice super Yang-Mills action. Eventually, each term in the action turns out to form closed loop, which ensures the manifest gauge invariance. The main advantage of this method is again that the action possesses exact super invariance w.r.t. all the lattice supersharges of the algebra. The fermions in the lattice SYM multiplet are realized on the links which connect integer sites to the neibouring half-integer sites. They consist again the Dirac-Kahler fermion on the lattice.

We still have a lot of things to be addressed, such as descrete Lorentz and R symmetry as well as the quantum aspect of the model, etc.. It is also important to proceed the above method to the higher-dimensional models including N=D=4 SYM theory which is currently under progress.

References

[1] A. D'Adda, I. Kanamori, N. Kawamoto and K. Nagata, "Twisted superspace on a lattice," Nucl. Phys. B **707**, 100 (2005) [arXiv:hep-lat/0406029].

[2] A. D'Adda, I. Kanamori, N. Kawamoto and K. Nagata, "Exact extended supersymmetry on a lattice: Twisted N = 2 super Yang-Mills in two dimensions," arXiv:hep-lat/0507029.