Dyonic Giant Magnons

Department of Physics, Faculty of Science, University of Tokyo,

Keisuke Okamura

E-mail: okamura@hep-th.phys.s.u-tokyo.ac.jp

The AdS/CFT correspondence predicts the spectrum of operator dimensions in planar $\mathcal{N}=4$ supersymmetric Yang-Mills (SYM) theory and the spectrum of a free string on $AdS_5 \times S^5$ are the same. In the talk I discussed the classical spectrum of string theory on $AdS_5 \times S^5$ in the so-called Hofman-Maldacena (HM) limit [1]. This is a recently invented limit where the problem of determining the spectrum simplifies considerably, in that on both sides of the correspondence the limiting theory is characterised by a centrally-extended $SU(2|2) \times SU(2|2)$ supergroup which strongly constrains the spectrum and S-matrix [2].

In the HM limit I concentrated on SYM operators with large $U(1)$ R-charge J_1, which therefore also have large scaling dimensions Δ ($\geq J_1$). More precisely, it is a limit where Δ and J_1 become infinite with the difference $\Delta - J_1$ and the 't Hooft coupling λ held fixed. In the spin chain description of the SYM theory, it is known there exsits an elementary excitation of the ferromagnetic vacuum known as a *magnon*. Recently it was shown in [3] that an infinite tower of boundstates of such magnons show up in the asymptotic spectrum. Magnons with polarisations in an $SU(2)$ subsector carry a second conserved $U(1)$ R-charge which I denote J_2, and they can form boundstates. The exact dispersion relation for such boundstates can be determined by the BPS condition to be

$$\Delta - J_1 = \sqrt{J_2^2 + \frac{\lambda}{\pi^2}\sin^2\left(\frac{p}{2}\right)}\,, \tag{1}$$

where p is the conserved momentum for the boundstates. These states should exist for all integer values of J_2 and for all values of λ [3]. In particular we are free to consider states where $J_2 \sim \sqrt{\lambda}$. For such states the dispersion relation (1) has the appropriate scaling for a classical string carrying two large classical angular momenta.

Following [4], I explained how to construct the corresponding classical string solutions with two independent angular momenta J_1 and J_2 on $\mathbb{R} \times S^3$ subspace of $AdS_5 \times S^5$ background, which exactly reproduced the relation (1). In static gauge, the string equations of motion are essentially those of a bosonic $O(4)$ sigma model supplemented by the Virasoro constraints. Exploiting the so-called Pohlmeyer's reduction procedure [5], the relevant classical solutions related to a family of soliton solutions of Complex sine-Gordon equation were constructed, which I called "Dyonic Giant Magnons". It is striking that the exact BPS dispersion relation (1) was reproduced from a purely *classical* calculation of the string theory.

Following [6], I further discussed the scattering of magnon boundstates and its counterpart in the string theory. Starting from the conjectured exact S-matrix for magnons in the $SU(2)$ sector [7,8], I presented the corresponding S-matrix for boundstates with an arbitrary number of constituent magnons. In the large-λ limit, the resulting gauge theory S-matrix was shown to agree precisely with the semiclassical S-matrix for the scattering of the Dyonic Giant Magnons.

References. [1] D. M. Hofman and J. M. Maldacena, arXiv:hep-th/0604135. [2] N. Beisert, arXiv:hep-th/0511082. [3] N. Dorey, arXiv:hep-th/0604175. [4] H. Y. Chen, N. Dorey and K. Okamura, JHEP **0609**, 024 (2006), [arXiv:hep-th/0605155]. [5] K. Pohlmeyer, Commun. Math. Phys. **46** (1976) 207. [6] H. Y. Chen, N. Dorey and K. Okamura, arXiv:hep-th/0608047. [7] N. Beisert, V. Dippel and M. Staudacher, JHEP **0407**, 075 (2004) [arXiv:hep-th/0405001]. [8] G. Arutyunov, S. Frolov and M. Staudacher, JHEP **0410**, 016 (2004), [arXiv:hep-th/0406256].