A New $\mathcal{N} = 4$ Membrane Action via Orbifold

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M-theory remains to be a mysterious subject even after more than ten years of intensive research. Perhaps one of the clues of this difficult topic is to ask the question: what is the theory on multiple branes (M2-branes and M5-branes) in M-theory?

Recently, Bagger, Lambert and Gustavsson (BLG) [1] proposed a Lagrangian description of the worldvolume theory on multiple M2-branes. The theory is three dimensional, has manifest $\mathcal{N} = 8$ R-symmetry and is believed to be superconformal, and thus satisfies some of the important conditions imposed on the worldvolume theory of M2-branes.

However, it should be stressed that we still do not have a proof that BLG theory is the theory on M2-branes. In my recent work in collaboration with Hiroyuki Fuji and Seiji Terashima [2], we thus studied a $\mathbb{Z}_2$-orbifold of BLG theory, obtaining a Lagrangian with $\mathcal{N} = 4$ supersymmetry which should be realized again on M2-branes.

This work serves as a non-trivial consistency check of the BLG theory as a candidate for theories on multiple M2-branes. First of all, even the fact that we can take orbifold of BLG theory is far from trivial since BLG theory have different matter contents as compared with worldvolume theories of D2-branes. Second, we have found that the classical vacuum moduli space of BLG theory exactly coincides with that of the strong coupling limit of worldvolume theory on a D2-branes. In fact, we found three branches in our vacuum moduli space, and the result is consistent in all three branches. Our analysis needs $O(4)$ (rather than $SO(4)$) gauge theory on D2-brane side, which suggest a small correction to the works of [3].

As a byproduct of our analysis, we also proposed a new non-perturbative duality (O-duality) interchanging $O2^-$-branes with orbifold $\mathbb{R}^4/\mathbb{Z}_2$ and $O2^-$-branes with D6-branes.

References

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[3] N. Lambert and D. Tong, Phys. Rev. Lett. **101**, 041602 (2008); J. Distler, S. Mukhi, C. Papageorgakis and M. Van Raamsdonk, JHEP **0805**, 038 (2008)