Open Wilson Lines and Holography in Noncommutative Field Theories

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In noncommutaitive gauge theory, translation group along noncommutative directions is (part of) noncommutative gauge group. This entails an important question regarding gauge-invariant, physical observables. I explain and motivate open Wilson lines as the (over)complete set of such observables. I clarify two confusing aspects of them: (1) whether gauge symmetry is the reason for opening Wilson loop into Wilson line and (2) how the Wilson lines are related to low-energy excitations. I resolve them by studying 1-loop effective action in noncommutative scalar field theory. Its nonplanar part shows that the low-energy dynamics is governed solely by <u>scalar</u> open Wilson line and that the effective action is strikingly reminiscent of <u>closed</u> string field theory. The interpretation is further supported by identical behavior of the kernel with the graviton two-point function in holographic dual gravity of noncommutative D3-brane.

Built upon this result, I proposed that open string theory is a complete microscopic definition of full string theory. I argue for this interpretation based on three distinct arguments.

(1) 't Hooft anomaly matching for $(D9 - \overline{D9})$ open string theory
I put forward a new interpretation of the Green-Schwarz mechanism as dynamical generation of closed strings at low-energy.

(2) Hagedorn temperature in open and closed strings theories
The Hagedorn temperature is seen as here-to-fore unknown phase transition point for closed strings, but as limiting temperature for open strings. Thus, in view of (1), the possibility is that closed strings <u>deconfine</u> into open strings, which then experience the Hagedorn temperature as the limiting temperature.

Non-Commutative Multi Solitons

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Understanding the geometry underlying string theory is clearly of great importance in the study of quantum gravity. It has been conjectured that open string field theory which is formulated in the language of noncommutative geometry may be a complete description of string theory. It is therefore important to gain some intuition for noncommutative geometry and this is precisely what is possible in studying noncommutative field theories. In fact, solitons in the simplest such theories– that of purely scalar fields, turn out to be analogues of D-branes.

Thus the study of multiple such solitons can give one an intuition about how D-branes see spacetime. My talk focussed on several novel aspects of multisoliton configurations in noncommutative scalar field theories. The basic approach is to study these in an expansion around very large noncommutativity. Using the isomorphism between operator multiplication in quantum mechanics and the noncommutaive Moyal product, the solitons are identified with projection operators. There is however a class of projection operators, which saturates a Bogomolnyi bound, that naturally define multisoliton configurations.

The corresponding parameter space of these solitons is finite dimensional and can roughly be thought of as parametrising the positions of the individual solitons when they are separated. There is some interesting structure to the moduli space when one brings the solitons together. This structure depends sensitively on the dimension of the theory. In the (2+1) dimensional theory one has a smooth configuration when one brings the solitons together. One finds a metric on the moduli space, which is Kahler. In (4+1) dimensions, bringing two solitons together naively has a singularity, but examination of the geometry of projection operators reveals that this singularity is resolved by an S^2. This is exactly as in string theory but is seen here in the noncommutative geometry of projection operators. When one goes to higher than (4+1) dimensions the structure of the moduli space gets more intricate and is isomorphic to what are known as Hilbert schemes. These turn out to have exotic singularities understanding which is likely to be important. From the point of view of mathematical physics too, it is interesting to explore many of the hints of integrable structure that underly the metric and other explicitly computable features of the theory.

BPS Walls and Junctions in NonLinear Sigma Models

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This works is in collaboration with Masashi Naganuma and Muneto Nitta, and is to appear as TIT/HEP-468.

We have studied BPS walls and junctions in $N = 1$ SUSY nonlinear sigma models in four spacetime dimensions. This study should be useful in its own right, and will serve as a starting point for a more difficult case of larger number of SUSY charges. Since nontrivial interaction among hypermultiplets requires nonlinear sigma models in $N = 2$ theories in four dimensions, we have to deal with features in nonlinear sigma models.

SUSY vacua in $N = 1$ nonlinear sigma models in four dimensions are classified into two types: Stationary points of superpotential, and singularities of Kähler metric. Holomorphic field redefinitions transmute these two types of vacua, but the total number of SUSY vacua is conserved except possibly the "runaway vacuum" at infinity.

We have found a Nonlinear sigma model with single chiral scalar field which admits BPS wall and junction solutions connecting any points in the moduli space.

We have also found nonlinear sigma models with several chiral scalar fields with Z_N symmetric discrete vacua, which admit Z_N symmetric BPS junction.