TIFR Annual Report 2000-01
THEORETICAL PHYSICS

String Theory and Mathematical Physics

Noncommutative gauge theory

A general formulation of gauge theories on noncommutative spaces was initiated. [Spenta Wadia, with L. Alvarez-Gaume (CERN)]

The formulation of noncommutative gauge theory was applied to study the noncommutative Nielsen-Olesen vortex solution and its topology in the noncommutative space. [Gautam Mandal and Spenta Wadia with D. Jatkar (HRI, Allahabad)]

A simple construction of a complete set of gauge-invariant operators in noncommutative gauge theory was given using the connection with the matrix model. [A. Dhar and S.R. Wadia]

Noncommutativity in string theory

When unstable D-branes in type II string theory are placed in a magnetic field, the resulting tachyonic world-volume theory becomes noncommutative. It was argued that for large noncommutativity parameter, condensation of the tachyon as a noncommutative soliton leads to new decay modes of the brane. This construction has led to a construction of unstable D-branes as solitons in a very simple and explicit way. [Sunil Mukhi, with K. Dasgupta and G. Rajesh (IAS, Princeton)]

D-branes constructed using noncommutative gauge theories, as mentioned above, are of even codimension, being based typically on spherically symmetric tachyon configuration. In this work, more general solitons, of a "squeezed" shape, are used to construct D-branes of odd codimensions. The calculation of the tension of such D-branes shows that these are T-dual to the ones with even codimension. [G. Mandal, with Soo-Jong Rey (Seoul National University, Korea)]

The couplings of a BPS D-brane with noncommutative world-volume coordinates to the RR-forms in superstring theories were written down in a manifestly background independent way. It was shown that these noncommutative Chern-Simons terms can be mapped to Myers terms on a collection of infinitely many D-instantons. Chern-Simons couplings for unstable non-BPS branes, and it was shown that condensation of noncommutative tachyons on these branes leads to the correct Myers terms on the decay products. [Sunil Mukhi and N. V. Suryanarayana]

Supergravity/String duals of Noncommutative gauge theories

Noncommutative gauge theories have been shown to have supergravity duals. However it has been difficult to obtain predictions from the supergravity side because of ambiguities in extracting boundary correlators. This work proposes an unambiguous way to extract correlators in a class of backgrounds which include these supergravity duals. This involves use of an operator form of the holographic relationship which allows a calculation of the boundary correlators from bulk Green's functions. [Sumit R. Das and B. Ghosh]

Using a generalization of the Myers effect it is shown how fuzzy surfaces other than the sphere, like CP^2 etc can arise. Also discussed are the holographic duals, these involve turning on RR and NS fluxes. [Sandip Trivedi and S. Vaidya]

The interlocking of gauge and translation invariance in noncommutative gauge theories implies that there are no local gauge invariant operators. However, the presence of gravity duals clearly show that there are gauge invariant operators with definite momentum. In this work it is proposed that these are the open Wilson lines constructed by Ishibashi et.al. The size of the Wilson line is proportional to the momentum. It is argued that the dual supergravity in fact displays this inverted IR/UV correspondence, by showing that the size of the hologram of a source increases (rather than decreasing as in the usual AdS/CFT correspondence) as the source moves closer to the boundary. [Sumit R. Das, with S.J. Rey (Seoul National University, Korea)]

In spite of the above identification of open Wilson lines as the duals of supergravity modes in the bulk, the precise form of the operator for a specific supergravity mode was hard to find. In this work we showed how to obtain these operators by considering a noncommutative gauge theory as a large-N matrix model expanded around an appropriate classical solution. The couplings of the matrix model (which is the theory of a set of zero branes or D-instantons) to supergravity backgrounds were then used to determine the correct operators in the noncommutative gauge theory. The proposal was checked by verifying that it is consistent with the Seiberg-Witten map relating noncommutative to ordinary gauge fields. The operators turned out to be straight Wilson lines in a direction transverse to the momentum with a suitable local operator smeared along it. [Sumit R. Das and S. Trivedi]

Wilson loop averages in 4-dimensional non-commutative superYang-Mills theory were investigated using the dual supergravity description. Under the assumption that the Wilson loops are located at the maximum of the dual metric in the (fifth) radial coordinate, it was shown that they exhibit a crossover from Coulomb type of behaviour for large loops, for which non-commutativity is unimportant, to area law for small loops, for which non-commutativity effects are large. [A. Dhar with Y. Kitazawa (KEK, Japan)]

High energy behavior of the correlation functions of open Wilson lines in noncommutative gauge theory was investigated. It was argued that the Wilson lines are bound to form a group of closed Wilson loops. This claim was proved in the weak coupling region by a perturbative analysis. A more general argument using the loop equation was also outlined. [A. Dhar with Y. Kitazawa (KEK, Japan)]

Non-critical Strings, RG flow and Holography

An RG flow equation satisfied by the regularized partition function for noncritical strings in background fields was derived. The flow refers to change in the position of a "boundary" in the liouville direction, which is required to regularize the ultraviolet divergences in the partition function coming from integration over world-sheets of arbitrarily small area. From the point of view of the target space effective gravitational action that the partition function evaluates on-shell, the boundary regularizes infrared divergences coming from the infinite volume of the liouville direction. The RG flow equation obtained in this theory looks very much like the Hamilton-Jacobi constraint equation that an on-shell gauge-fixed gravitational action must satisfy. [A. Dhar and S.R. Wadia].

Giant graviton states

In the AdS/CFT correspondence BPS states in the boundary gauge theory have R-charges which are bounded by the rank of the gauge group. This implies that the corresponding states in supergravity or string theory should have a bound on the angular momentum. To understand this "stringy exclusion principle" it has been proposed that for large angular momenta the states which are dual to the gauge theory states with the same R charge are not perturbative modes, but "giant gravitons"- extended branes wrapped around spheres. Unlike usual extended objects with tension they have a gapless dispersion relation which is in fact exactly the same as that of a supergravity mode with the same angular momentum. In a series of works it is shown that (a) the giant graviton energy satisfies a BPS bound, being always less than the angular momentum (b) the BPS saturated state corresponds to a special motion which implies an effective noncommutativity of the space on which it moves (c) the vibration spectrum around such BPS states is independent of the size of the brane as opposed to usual extended objects whose frequencies scale with their inverse size. The underlying mechanism for these unusual properties was elucidated. [Sumit R. Das with A. Jevicki (Brown University, U.S.A.) and S.D. Mathur (Ohio State University, U.S.A.)]

Giant Gravitons exemplify a phenomenon expected to be quite general in string theory - namely the growth in transverse size of moving objects. It is shown that for some cases the Giant Graviton phenomenon can be related to a magnetic analogue of the Myers' effect. For example in a background magnetic RR field moving D0 branes puff up into a fuzzy sphere, which can be interpreted as an expanded D2 brane. It is also shown that the giant graviton states with gapless dispersion relation exist not only for AdS space-times, but for a wide variety of other space-times, including those with no supersymmetry. In particular they exist in the geometry of extremal and non-extremal Dp branes in string theory. [Sumit R. Das, S. Trivedi and S. Vaidya]

Non-BPS States in String Theory/Supergravity

Stable non-BPS states are constructed and studied in a variety of contexts in string theory. Interesting constructions arise from branes at singularities. Among these, some novel stable non-BPS states were discovered and identified with their holographic duals. [Sunil Mukhi and N. V. Suryanarayana]

Supergravity solutions are constructed that correspond to N Dp-branes coinciding with $\bar{N}\bar{D}p$-branes. The physical properties of the solutions are studied, pointing to a possible supergravity description of tachyon condensation. An interpolation between the brane-antibrane solution and the Schwarzschild black hole is also constructed. [Gautam Mandal with Philippe Brax (CERN, Switzerland and Saclay, France) and Yaron Oz (CERN, Switzerland)]

More mathematical aspects

A duality in W-geometry was studied from several viewpoints. Laguerre-Forsyth invariants were studied under a duality transformation as well W-geometry embeddings of curves in projective space. It was found that this duality coincides with a duality transformation for curves in projective space found by the mathematician Ragni Piene a few years ago. [I. Biswas (School of Mathematics) and A.K. Raina]

A-type and B-type D-branes are constructed in the gauged linear sigma model by considering worldsheets with boundary. The construction brings out various aspects of D-branes on curved manifolds. Using the non-linear sigma model as a guide, several features of D-branes on Calabi-Yau manifolds are also studied, as well as the conjectured correspondence between Chern-Simons gauge theory and topological string theory on the resolution of the conifold. Non-trivial checks are performed for new polynomial invariants by comparing them with topological string amplitudes on the resolved conifold, in the presence of D-branes. [Tapobrata Sarkar with Suresh Govindarajan (IIT, Chennai), T. Jayaraman (IMSc, Chennai) and P. Ramadevi (IIT, Mumbai)]