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THEORETICAL PHYSICS

String Theory and Mathematical Physics

String Theory

Gravitational Couplings, Orientifolds and M-Planes

String-theory orientifold planes of various types including the Sp and SO-odd planes were examined, and the gravitational Chern-Simons couplings on their world-volumes deduced. It was shown that when an orientifold 3-plane crosses a 5-brane, the jump in the charge is accompanied by a corresponding change in the gravitational couplings. (Nemani V. Suryanarayana and Sunil Mukhi)

Brane-Antibrane Constructions

In type II string theories, intersecting brane constructions were proposed that contain brane-antibrane pairs suspended between 5-branes. Various models with distinct physics were identified: parallel brane-antibrane pairs, adjacent pairs, non-adjacent pairs, and "Borromean" configurations which break all supersymmetry even though any pair of branes preserves some supersymmetry. Some of the brane constructions were mapped by duality to systems of brane-antibrane pairs at orbifold singularities, enabling an explicit derivation of the spectra by a quiver construction. (Nemani V. Suryanarayana, Sunil Mukhi and David Tong).

This work led to the discovery of a novel tachyon-free stable non-BPS brane configuration in type IIA string theory, which is dual to a fractional brane-antibrane pair placed at a conifold singularity. The stable configuration was shown to exhibit a phase transition as a function of brane separation. (Nemani V. Suryanarayana and Sunil Mukhi)

Fractional Branes and Anti-deSitter Domain Walls

The relationship among domain walls in Anti-deSitter space, fractional branes and branes stretched on intervals was explored. Some parallels were drawn between the Anti-deSitter background with domain walls and supersymmetric MQCD, and various extended objects in Anti-deSitter space were identified in the dual brane construction. (S. Mukhi with K. Dasgupta of IAS, Princeton)

Supersymmetric Anti-deSitter Orbifolds

The behaviour of Killing spinors on 5-dimensional Anti-deSitter space under various discrete symmetries of the spacetime was examined. In this way a number of supersymmetric orbifolds were discovered, reproducing the known ones and adding some novel ones to the list. (Bahniman Ghosh and Sunil Mukhi)

Holograms of Branes in the Bulk and Acceleration Terms in SYM Effective Action

In the conjectured AdS/CFT correspondence strongly coupled large-N gauge theory in 3+1 dimensions is dual to supergravity in five dimensional anti-de-Sitter spacetime. It is puzzling how causality in five space time dimensions is respected by the four dimensional gauge theory on the boundary. A good starting point is to understand how the retarded interaction between gauge field excitations on two test 3-branes in $AdS_5 \times S^5$ appears in the holographic gauge theory description. It was conjectured that the retarded nature of the interaction shows up as acceleration terms - terms with derivatives of gauge fields - in the Yang-Mills effective action. An explicit calculation showed that the lowest order accleration term predicted by supergravity is indeed exactly reproduced in the one-loop effective action and a nonrenormalization theorem ensures that this term is exact and hence has an overlapping regime of validity with supergravity. (Sumit R. Das)

D-branes on Calabi-Yau Manifolds

The behaviour of D-branes on Calabi-Yau manifolds was investigated using the gauged linear sigma model. At large values of the gauge coupling, it is shown that this model, with open string sectors naturally give rise to a non-commutative setup with a B-field proportional to the inverse radius of the Calabi-Yau. An attempt is made to understand the implications of this at generic gauge couplings when quantum corrections become important. The behaviour of D-branes is studied in this limit and the results are shown to be consistent with Matrix theory. Attempts are on to generalise these results for some two-parameter Calabi-Yau models. (T. Sarkar, with S. Govindarajan of IIT, Madras and T. Jayaraman of IMSc, Madras)

D-branes on Abelian Orbifolds

The problem of D-brane gauge theories on Abelian orbifolds was investigated via toric geometry. Earlier results on extracting the gauge theory data from the geometry data have been generalized for some Calabi-Yau three and four folds. Some interesting cases of toric duality have also been investigated. (T. Sarkar)

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Black Holes, Strings and Noncommutative Geometry

Discrete Flux as Quantum Hair

Yang-Mills theory was investigated on a spatial torus at finite temperature in the presence of discrete electric and magnetic fluxes using the AdS/CFT correspondence. The leading dependence of the partition function on the fluxes was calculated using the dual supergravity description. These fluxes were interpreted as discrete quantum hair for black holes in AdS spacetime. (A. Dabholkar and S.P. Trivedi)

Point Mass Geometries, Spectral Flow and AdS_3/CFT_2 Correspondence

A one-parameter family of (asymptotically AdS) conical geometries, which are generated by point masses and interpolate between AdS and BTZ spacetimes, was discussed in terms of the AdS/CFT correspondence. This family of geometries was shown to correspond to spectral flow in $N = (4, 4)$ SCFT$_2$ and to interpolate between NS and R sectors. This was accompalished by representing the conical spaces as solutions of three-dimensional supergravity based on the supergroup $SU(1, 1|2) \times SU(1, 1|2)$. The boundary CFT used is based on the D1/D5 system. The correspondence includes comparing the Euclidean free energies between supergravity and SCFT for the family of conical spaces including BTZ black holes. (G. Mandal, S. Vaidya and S.R. Wadia)

D1/D5 Moduli in SCFT and Gauge Theory, and Hawking Radiation

Marginal operators of the orbifold SCFT corresponding to all twenty near-horizon moduli in supergravity, including operators involving twist fields, which correspond to the blowing up modes, were constructed and identified with the supergravity moduli in a 1-1 fashion by inventing a global SO(4) algebra in the SCFT. The gauge dynamics of the D1/D5 system relevant to the splitting $(Q_1, Q_5) \rightarrow (Q'_1, Q'_5) + (Q''_1, Q''_5)$ was analysed with the help of a linear sigma model. It was shown, in supergravity as well as in SCFT, that the absorption cross-section for minimal scalars is the same all over the near-horizon moduli space. (J.R. David, G. Mandal and S.R. Wadia)

D1/D5 System with B-field, Noncommutative Geometry and the CFT of the Higgs Branch

The D1/D5 system was considered in the presence of the NS B field. An explicit supergravity solution in the asymptotically flat and near horizon limits was presented. Explicit mass formulae were given in both cases. This solution has no D3 source branes and represents a true bound state of the D1/D5 system. The motion of a separated D1-brane in the background geometry described above was studied and shown to reproduce the Liouville potential that binds the D1 brane. A gauge theory analysis was also done in the presence of Fayet-Illiopoulos parameters which can be identified with the self-dual part of the NS B

field. In the case of a single D5-brane and an arbitrary number of D1 branes, the existence of a bound state in the Higgs branch was demonstrated. Connection of the SCFT on the resolved $\mathrm{Sym}_{Q_1 Q_5}(\tilde{T}^4)$ with recent developments in non-commutative Yang-Mills theory was pointed out. (A. Dhar, G. Mandal, S.R. Wadia and K.P. Yogendran)

D-instantons in Supergravity with Nonzero B Field

Recently it has been shown that in the presence of a constant 2 form NSNS gauge field on a brane, a new low energy limit can be defined in which the effective field theory is noncommutative Yang-Mills (NCYM) theory on the brane worldvolume. A dual description of NCYM theory in terms of a supergravity background has also been suggested. D-instanton solutions in this supergravity background with self dual 2-form fields were constructed and argued to be dual descriptions of instantons in NCYM theory. It was shown that the action is correctly reproduced and the location of the D-instanton is related to the scale size of the NCYM instanton. The D-instanton can be located anywhere in the bulk, which crresponds to the fact that instantons in NCYM theory can have any size provided the 2-form field is self-dual. For large instantons this relationship was shown to be identical to that in the usual AdS/CFT correspondence and corrections can be computed as a power series in momentum. (Sumit R. Das and S.P. Trivedi with S. Kalyana Rama of IMSc, Madras)

Quantum Field Theory

Generalised Projective Structures

The concept of a generalised projective structure was formalised and shown to come in several canonically equivalent ways: through the geometric approach to the operator product expansion, in terms of global differential operators on a Riemann surface, in terms of projective structures and higher spin fields, a generalisation of Deligne's definition, and in terms of an analytic immersion of the curve in projective n-space equivariant with respect to its symmetry group. An involution was found on the space of such structures, appearing naturally from the the work on the geometric approach to the operator product expansion, which is trivial for ordinary projective structures but non-trivial for these generalised projective structures. Its meaning was found in each case and in the case of differential operators was found to be a global notion of an adjoint which locally corresponds to the classical Lagrange adjoint of a differential operator. This involution also acts correctly on the classical Lagrange-Forsyth invariants of the differential operators. (I. Biswas and A.K. Raina)

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