

# TIFR Annual Report 2002-03

## THEORETICAL PHYSICS

### String Theory and Mathematical Physics

#### Closed String Tachyon Potential Calculation

The closed string 4-Tachyon amplitude in  $C/Z_N$  orbifold was calculated. In an appropriate large  $N$  limit, this will throw some light on the behaviour of closed string tachyon potential in target space. [Allan Adams, Atish Dabholkar, Ashik Iqbal, Joris Raeymaekers]

#### Compactification by Duality Twists

The Scherk-Schwarz potential generated by string theory compactifications was investigated in the case of twists belonging to the duality group. For some twists, such twisted compactifications are equivalent to introducing internal fluxes. [Atish Dabholkar, Ashik Iqbal, Prasanta Tripathy, Sandip Trivedi]

#### Duality twists, Fluxes, and Orbifolds

An important problem in string theory is to generate a potential for the unwanted massless moduli fields. With this motivation, compactifications with duality twists and their relation to orbifolds and compactifications with fluxes were investigated. Inequivalent compactifications were classified by conjugacy classes of the U-duality group and resulted in gauged supergravities in lower dimensions with nontrivial potential on the moduli space. It was shown that the potential has a stable minima precisely at the fixed points of the twist group and that the theory at the minimum has an exact CFT description as an orbifold. The implications of these results for moduli stabilization is under investigation. [Atish Dabholkar with Chris Hull]

#### Tachyon Condensation in String Theory

Usually F-theory duals of string theory are considered for supersymmetric backgrounds. F-theory duals of certain nonsupersymmetric backgrounds were considered that have localized tachyons. Some speculations about the endpoint of the tachyon condensation were presented based on this duality. [Atish Dabholkar]

## Decay of $C/Z_n$ orbifold: Exact supergravity solution.

The exact time-dependent supergravity solution corresponding to the decay of the unstable  $C/Z_n$  orbifold was constructed. This confirmed a conjecture made previously in work by Adams, Polchinski, and Silverstein regarding the nature of this decay. It also may allow a comparison with the renormalization group description of the same decay. [Matthew Headrick]

## String compactifications with flux

Supersymmetric compactification of string theory was studied in the presence of a background flux. Because of the nontrivial background flux, it is possible to obtain supersymmetric solution even when the compact manifold is not a Calabi-Yau space. This was shown by explicitly constructing few examples. Moduli stabilization was also studied in type *IIB* compactification with flux on  $K3 \times T^2$ . [P.K. Tripathy and S.P. Trivedi with S. Kachru and M. Schulz]

## De Sitter vacua in string theory

The first construction in the literature of string theory of vacua with positive cosmological constant was presented, where the supersymmetry breaking is controlled and all moduli are lifted. [S.P. Trivedi with S. Kachru, R. Kallosh and A. Linde]

## Gauge-string duality

The gauge theory dual to string theory on a plane wave background with a compact null direction was constructed. This provides the setting to carry out the discrete light-cone quantisation (DLCQ) of the string theory. The gauge theory is found to be an  $N=2$  supersymmetric quiver gauge theory corresponding to branes at an orbifold singularity, in a double-scaled limit where the order of the orbifold group and the rank of the gauge group are scaled to infinity together. This limit is related in a subtle way to previous ‘deconstruction’ proposals for higher-dimensional gauge theories. After T-duality, the quiver diagram provides an explicit discretisation of a non-relativistic closed string. [Sunil Mukhi with Mukund Rangamani and Erik Verlinde]

## Noncommutative string theory

Couplings between open and closed superstring theory were studied in the noncommutative description, It was shown that the entire tree-level amplitude to leading order in open-string fields is described by a new metric-dependent deformation of a certain “star” product. This is

interpreted in terms of a deformed (non-associative) version of the Moyal star product. The new proposal follows from a boundary-state amplitude computation in commutative string theory, and comparison with the corresponding computation on the noncommutative side. These results were then used to examine the possible role of Wilson lines in constructing gauge invariant operators beyond the limit of large magnetic fields (“Seiberg-Witten limit”). [Sunil Mukhi and Nemani V. Suryanarayana]

## String bits in small radius AdS and $N = 4$ Super Yang-Mills theory

Quantization of *IIB* strings in the light-cone gauge was studied in  $AdS_5 \times S^5$  for small radius in Poincaré coordinates. A picture of strings made up of noninteracting bits emerges in the zero radius limit, each independent bit behaving like a superparticle moving in the  $AdS_5 \times S^5$  background, carrying appropriate representations of the super conformal group  $PSU(2, 2|4)$ . The standard Hamiltonian operator which causes evolution in the light-cone time has continuous eigenvalues. Identification was made of operators in the light-cone gauge which have discrete spectra and are more appropriate for comparison with the SYM theory on the boundary. States of the free string were constructed in this basis. All possible states arising from discretizing the string into varying number of bits were included. A non-zero value of the radius introduces interactions between the bits and the spectrum of strings gets modified. The leading perturbative corrections at small radius were discussed for a few simple cases. Potential divergences in the perturbative corrections, arising from strings near the boundary, cancel. It was suggested that the divergences cancel in the computation of anomalous dimensions of all physical string states because of the large amount of supersymmetry present in the  $AdS_5 \times S^5$  background. This work provides a first step for a rigorous and detailed testing of the *AdS/CFT* conjecture. [A. Dhar, G. Mandal and S.R. Wadia]

## Aspects of string propagation in $AdS_5$

An infinite number of conserved currents and charges were found in the semiclassical limit  $\lambda \rightarrow \infty$  of string theory in  $AdS_5 \times S^5$  and their relevance to conserved charges in the dual gauge theory was remarked. A general procedure for exploring the semiclassical limit was established by viewing the classical motion as collective motion in the relevant part of the configuration space. The procedure was illustrated for semiclassical expansion around solutions of string theory on  $AdS_5 \times (S^5/Z_M)$ . [Gautam Mandal, Nemani V. Suryanarayana, Spenta R. Wadia]

## Holography in Plane Wave backgrounds

The Penrose limit of  $AdS \times S$  backgrounds was viewed from the point of view of symmetry breaking. For a  $AdS_{d+1} \times S^{\bar{d}+1}$  background the isometry group  $SO(d, 2) \times SO(\bar{d} + 2)$  is

“broken” to  $SO(d) \times SO(\bar{d}) \times H(d) \times H(\bar{d})$  by the Penrose limit, where  $H(d)$  denotes the Heisenberg group. Even though the number of isometries remain the same, the generators of  $H(d) \times H(\bar{d})$  do not commute with the light cone hamiltonian and are thus “broken”. There are  $d + \bar{d}$  Nambu-Goldstone modes, which appear as the oscillators generating the string spectrum. These isometries have a natural action on the plane transverse to the plane wave, which suggested that one may regard  $x^+$  as a holographic direction. [Sumit R. Das with C. Gomez and S.J. Rey]

The symmetry breaking aspect was then studied from the point of view of the original dual gauge theory, and the precise manner in which the conformal algebra contracts to products of rotation and Heisenberg algebras when acting on states with large R charge  $J$  was analyzed. Using a free field approximation it was shown that this process of contraction restricts all the gauge theory fields to a few low angular momentum modes, and ensures that fields with negative R charge do not appear in the spectrum of operators creating supergravity states. This provides an understanding of several important aspects of the gauge theory-gravity correspondence in this context. [Sumit R. Das with C. Gomez]

## Vertex algebras

A theory of completion for filtered associative algebras was developed for application to the theory of vertex algebras. [A.K. Raina]

## Conformal field theory

Investigations were made on studying the link between moduli spaces of vector bundles on a compact Riemann surface, arising in Conformal Field Theory, and generalised theta functions. [A.K. Raina, work in progress with I. Biswas]