TIFR Annual Report 2003-04
THEORETICAL PHYSICS

String Theory and Mathematical Physics

Highlights

Research in String Theory was carried out on a very broad front, encompassing mirror symmetry, matrix models, duality, compactifications, the study of string theory in a curved background and its relation to gauge theories, and the interaction of string theory with cosmology.

Some progress was made towards quantizing string theory in $AdS_5 \times S^5$ in the limit of zero curvature, which is dual to the free limit of $N = 4$ Super Yang-Mills in four dimensions.

A topological matrix model that encodes the scattering amplitudes of noncritical string theory was reformulated as a model with a matrix Liouville potential and open-string tachyon effective actions were investigated.

The rolling tachyon of 2-dim. string theory was discussed as a non-commutative soliton in the c=1 matrix model. The solution is non-perturbative in the string coupling and leads to a finite calculation of D0 brane decay.

Closed string tachyon condensation was studied in the C/Z_N orbifold. An exact supergravity solution describing the decay was found, and the orbifold at large N was shown to be dual to a supergravity system.

An Inflationary Model in String Theory was constructed.

Mirror symmetry was extended to the heterotic string.

A possible generalisation of the Fay trisecant identity to vector bundles was identified.

TEXT

Mirror symmetry

Mirror symmetry was extended to the heterotic string (with A. Basu and S. Sethi); counterexamples were provided to the g_{cl} conjecture; it was shown that LISA will be an effective probe of galactic halo dark matter (with J. Bloom). [Allan Adams]

Calabi-Yau compactifications

Conventional Calabi-Yau compactifications leave a high number of moduli-fields, but the existence of flux can greatly reduce the number of such free parameters. While it has been known that the "complex structure moduli" are fixed in the presence of RR- and $NSNS$-fluxes, we consider explicit examples where a potential for the Kähler moduli is generated by these fluxes via non-perturbative effects. [Lars Goerlich, P.K. Tripathy, S. Trivedi]

We studied examples of string theory compactifications on some Calabi-Yau manifolds by turning on nontrivial RR and NS flux, which are analogues to the flux due to magnetic fields in electrodynamics. We obtained both supersymmetric as well as nonsupersymmetric solutions by stabilizing all complex structure moduli as well as some of the Kähler moduli, whereas the overall size of the Calabi-Yau manifold remained undetermined. In addition, we investigated several predictions about the properties of the flux vacua by constructing and characterizing a very large set of vacua in this example. [Prasanta Kumar Tripathy]

Superstrings in $AdS_5 \times S^5$

Continuing our investigation of superstrings propagating in the $AdS_5 \times S^5$ background, a major step towards quantization of this theory in the limit of very small AdS radius (small string tension limit) in the light-cone gauge was taken with the construction of a lattice regularized version of the superconformal generators. These generators satisfy the superconformal algebra upto terms that vanish in the naive continuum limit. Particular attention to correct discretization of x^- was needed, since this introduces non-locality in the superconformal generators. In principle, with this explicit construction of the generators available, representations of the superconformal algebra can now be constructed in the limit of zero AdS radius. For Maldacena duality to be valid at weak Yang-Mills coupling also, these representations should be in one-to-one correspondence with gauge invariant operators of the $N = 4$ Super Yang-Mills theory. Work to check this is in progress. [Avinash Dhar]

Topological matrix models

Topological matrix models related to the noncritical string at self-dual radius were analysed. These include the Penner model and the W-infinity model, which have different origins but are equivalent to each other. It was shown that these models are also equivalent to a Liouville matrix model, and it was proposed that this could be interpreted in terms of N D-instantons of the c=1 string. [Sunil Mukhi]

Tachyon effective actions

The validity of open-string tachyon effective actions was analysed and a methodology to obtain systematic corrections to it was investigated. The action, along with suitably defined

derivative corrections, can be read off from the scattering amplitudes of open-string states. [Anindya Mukherjee, Sunil Mukhi]

Rolling tachyon

A classical (string) field theory of $c = 1$ matrix model which was developed earlier, was considered. This is a noncommutative field theory where the noncommutativity parameter is the string coupling g_s. A classical solution of this field theory was constructed and shown to describe the complete time history of the rolling tachyon on an unstable D0 brane. The solution is essentially non-perturbative in the string coupling and incorporates stringy effects and back reaction. [G. Mandal, S.R. Wadia]

D-branes, tachyons, compactifications

Off-shell interactions for localized closed-string tachyons in C/Z_N superstring backgrounds were analyzed and a conjecture for the effective height of the tachyon potential was elaborated. The cubic interaction between nearly-massless tachyons with different charges was shown to vanish, and it was also shown that to leading order in N, the quartic contact interaction vanishes and the massless exchanges completely account for the four point scattering amplitude. [Atish Dabholkar, Ashik Iqubal and Joris Raeymaekers]

Interactions of Dirichlet branes in plane wave background are analyzed. It is shown that effective brane tensions and RR charges for these branes take the same values as in Minkowski space. [Atish Dabholkar, Shahrokh Parvizi, Joris Raeymaekers]

The relation between duality twisted reductions and Scherk-Schwarz reductions is explored further. It is shown that some duality twisted compactifications cannot be viewed as Scherk-Schwarz reductions and vice versa. A general formula for the scalar potential is proposed within gauged supergravity that encompasses both cases. [Atish Dabholkar with Chris Hull (Imperial College, London)]

Tachyon condensation

The C/Z_N orbifold of type II string theory is the simplest and best studied system for the study of localized closed string tachyon condensation. A simple method was found to derive the general exact solution describing monopole scalar radiation coupled to gravity in 2+1 dimensions, which confirms the conjecture of Adams, Polchinski, and Silverstein regarding the late time behavior of the decay of the orbifold. Furthermore, it was shown that at large N the orbifold is related by mirror symmetry to a simple gravity background, and that some of the tachyons of C/Z_N are reflected in this dual picture as Gregory-Laflamme-like gravitational instabilities. [Matthew Headrick]

String theory model of inflation

A model of inflation in string theory was constructed after carefully taking into account moduli stabilization. The setting is a warped compactification of Type IIB string theory in the presence of D3 and anti-D3-branes. The inflaton is the position of a D3-brane in the internal space. By suitably adjusting fluxes and the location of symmetrically placed anti-D3-branes, we showed that at a point of enhanced symmetry, the inflaton potential V can have a broad maximum, satisfying the condition $V^{''}/V \ll 1$ in Planck units. On starting close to the top of this potential the slow-roll conditions can be met. Observational constraints impose significant restrictions. As a first pass, it was shown that these can be satisfied and determine the important scales in the compactification to within an order of magnitude. One robust feature is that the scale of inflation is low, $H = \mathcal{O}(10^{10})$ GeV. Removing the observational constraints makes it much easier to construct a slow-roll inflationary model. Generalizations and consequences including the possibility of eternal inflation were also discussed. [Norihiri Iizuka, Sandip P. Trivedi]

Mathematical Physics

An important open problem is to find a satisfactory generalisation of the Fay trisecant identity to vector bundles and generalised theta functions, whose section count is given by the Verlinde formula. A conjectural formulation of this has been found which is geometrically elegant. [A.K. Raina with I. Biswas]