STRINGS 2001

CONFERENCE SUMMARY

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The unifying theme that
accounts for the vast majority
of the talks at Strings 2001 is:

D BRANES

There were a few talks not
directly related to D-branes
that were more speculative
and introduced NEW DIRECTIONS.
I will discuss these first &
then turn to the D-brane topics.

NEW DIRECTIONS

HORAVA   "de Sitter Entropy
              and String Theory"

Our universe seems to have $\Lambda > 0$.
Is this possible in string theory?
Approach: study quantum theory
defined by Hamiltonian of an
inertial observer. Finite # of
degrees of freedom ~ cosmological horizon

HULL   "Strongly Coupled Limit
 of M theory & Conformal Invariance"
       Start with M theory on $\mathbb{R}^5 \times T^6$
and consider $L_{PL} \to \infty$. Is there
a conformally invariant theory in 6d
with $(4,0)$ susy? $OSp(8|8)$, $E_6(\mathbb{Z})$
What replaces geometry?

RUSSO   M Theory at Finite Temperature

One loop free energy shows Hagedorn transition

for $T_{cr} \sim .31\, \ell_p^{-1}$ — connects smoothly to IIA

result. Implications for microscopic degrees of freedom?

HAWKING   AdS, CFT, & Cosmology

Trace anomaly driven inflation. For large N

instanton $\gg \ell_{pe} \to$ de Sitter. Instability

triggers inflation. Benign ghosts?

KAZAKOV & KUTASOV   Matrix Model of 2D Black Hole

Old matrix model of 2D bosonic string

used to analyze "Cigar" geometry

— euclidean 2d black hole. Key ingredient

is equivalence of $\dfrac{SL(2,C)}{SU(2) \times U(1)}$ coset

model and a Sine-Liouville model.

Compactified on circle, introduce vortices

via twisted periodic b.c. $\sim$ Toda Hierarchy.

Witten **Quantum Gravity in de Sitter Space**

- No positive conserved energy, therefore susy is impossible.

- If $N \sim \exp\left(\frac{1}{G_N^2 \Lambda}\right)$ (à la Banks), this suggests GR cannot be quantized and needs to arise from more fund. theory

- Only asymptotics are $t \to \pm \infty$, so only observables are $\langle f | i \rangle$.

- Asymptotic dS cosmology is "unpleasant" (Dyson)

- A conservative option is $\Lambda = 0$ with some sort of "quintessence" such as
  - slowly rolling dilaton (severely constrained)
  - an axion-like field with $V(a) \propto 1 + \cos a$.

D-BRANE TOPICS

① AdS/CFT Duality & Generalizations

② Unstable Systems & Tachyon Condensation

③ Noncommutative Field & String Theories

④ D-Brane Effective Actions

⑤ ~~Matrix Theory & M Theory~~

⑥ D-Branes Wrapped on Calabi-Yaus

⑦ Brane Worlds & Large Extra Dimensions

(D1): AdS/CFT Duality, Generalizations, and Nonperturbative Gauge Theory

CVETIC **Brane Resolution on Ricci-Flat Metrics**: Constructed smooth $\mathcal{N}=2$, $D=5$ supergravity solutions that are viable duals of $\mathcal{N}=1$, $D=4$ large N field theories. The key to avoid singularities is to add suitable fluxes with $dF_n = F_p \wedge F_q$. "Resolution via transgression"

VERLINDE **Challenge for String Theory and Holography**
Gave a "wish list" including microscopic deriv. of holographic RG eqns, etc.

GUBSER Phase Separation

- Proposed that Gregory-Laflamme instability occurs wherever there is thermo. instability. Illustrated with near extremal spinning brane.

- Also discussed Stanford D-brane model for fractional quantum Hall state. Appears plausible for a range of ν.

GROSS An Exact Prediction of $N=4$ SYM and Comparison with String Theory

For a circular BPS Wilson loop

$$W_0(\lambda = g^2 N, N) = \frac{1}{N} L^1_{N-1}\left(-\frac{\lambda}{4N}\right) e^{\lambda/8N}$$

Conformal equiv to straight line which has $W=1$. Conformal anomaly at pt that maps to ∞ gives the result — evaluated using matrix model methods.

Agrees with dual theory to leading order in α' + all orders in $1/N^2$.

GREEN Connections Between Large N
SYM and String Theory

- Gave a lightning review of his
derivation of R^4 and λ^{16} terms in
the string effective action.

- Proposed generalizing Gross' analysis
to instanton backgrounds. Nonzero?

NARAIN D1/D5 Systems in Theories
with 16 Supercharges

GIVEON Superstrings on AdS_3

PEET More on Singularity Resolution
    Explored where Tension of brane probe
variodes in $\eta = 2^*$ flow geometry of
Pilch-Warner — enhancon.

DOREY   Exact Results in $\mathfrak{N} = 1^*$

Susy-YM and Its String Dual

Want to extrapolate from $\Lambda \sim M$

to $\Lambda << M$. $\Lambda \sim M e^{-2\pi/3\lambda}$

The idea is compute $\overset{exact}{\underset{\wedge}{}}\lambda$ dependence of

various holomorphic quantities & thereby

make predictions of stringy corrections to sugra.

KLEBANOV Supergravity Dual of a

Confining Cascading Gauge Theory

    Beautiful work with Strassler & others

achieved supergravity dual of Seiberg duality

$IR \cdots \to SU(N) \times SU(N-M) \to SU(N+M) \times SU(N) \to \cdots$ UV

SCHOMERUS Brane Dynamics in CFT Backgrounds

   Branes on $SU(2)_k$, etc.

BACHAS D-D D-Branes in the $SL(2,R)$

WZW Model

   Twisted conjugacy classes

(D2) : Unstable Systems, Tachyon
Condensation, and Solitons

KRAUS BSFT Approach to the $D\bar{D}$ System

Very clear explanation of BSFT Computations

Using : bulk wave functionals,

Quillen superconnection, boundary fermions,

ABS construction of solitons , ...

ZWIEBACH Tachyon Dynamics + String Field Theory

a) Successful guesses of tachyon eff. action

b) Attempt to guess true vacuum ϕ_0 of

the cubic bosonic string field theory. Asso.

BRST Charge mode of ghosts (e.g. c_0).

SEN Lump Solutions in String Field

Theory Around the Tachyon Vacuum.

Using above obtain n-pt Green's fns up to normalizations.

of there are suitable branch points, then
$\frac{\delta W}{\delta J}$ on second sheet gives ϕ_0. Can then
compute tension ratios for lump
solutions representing lower dim D-branes.

TAYLOR Gauge Invariance and Tachyon
Condensation in Open String Field Theory.
Level truncation gave a piece of
$V(\Phi)$ The end point
branch points are due to breakdown
of Feynman–Siegel gauge $b_0 | \Phi \rangle = 0$.

SHATASHVILI Field Theory of Open Strings,
Tachyon Condensation and Closed Strings
BSFT calculation of exact tachyon
potential. Addition of gauge fields.
Evidence that open strings disappear at
true min + closed strings are dynamical.

(D3) : <u>Noncommutative Gauge Theory</u>

<u>and String Theory</u>

GOPAKUMAR, MINWALLA, HARVEY

Noncommutative Solitons

D-branes in bosonic string theory
were described as solitons in
noncommutative field theories. The
scalar field theory of a "tachyon" in $2+1$ dim
has solitons that describe the codim $=2$
D-brane in the limit $\theta \to \infty$.

For the noncomm. $U(1)$ gauge theory
exact solutions are obtained for finite θ :

$$C = (S^+)^m a^+ (S)^m \text{ where } S = \sum |i\rangle\langle i+1|$$

This describes m D0-branes on
top of a D2-brane.

SURYANARAYANA RR Couplings of Noncommutative Braves

Nncomm. analogs of the Nonabelian D-brane formulas of Myers.

DAS — Bulk Couplings To Noncommutative Braves

OOGURI — How Noncommutative Gauge Theories Couple to Gravity

These two talks showed that the gauge invariant operators that couple to bulk fields involve straight Wilson lines. Ooguri showed that T_{ij} starts at lower power of α' in noncommutative theory than in the commutative one. The dual gravitational description was discussed.

KITAZAWA Wilson Lines in Noncomm.
Gauge Theories

Formal large N limit of matrix models

REY Classical & Planar Limits of
Noncommutative Vacua and Solitons

Studied quantum deformation
of GMS solitons. Probes $V(T)$
away from the extrema in $\theta \to \infty$ limit.

MANDAL Matrix Model, Noncomm.
Gauge Theory, and Brane-Antibrane Systems

BFSS matrix model demonstrated
to be very effective for these purposes.

(D4) ~~D-Brane~~ D-Brane

Effective Actions

MYERS   Fuzzy Funnels — Non-Abelian

Brane Intersections

D-strings ending

on $D-(2n+1)$ - branes

Understand both ways: $\int C^{(2)} \wedge tr (F_\wedge \cdots \wedge F)$

+ Myers' effect

TRIVEDI   Magnetic Branes & Giant Gravitons

Magnetic analog of Myers dielectric effect

Moving objects in magnetic field grow in

transverse dimensions to radius $R \propto v$.

GHOSHAL   Normalization of the BSFT Action

Completes check of Sen conjecture in BSFT.

JHS   Comments on Born-Infeld Theory

(D6) D-Branes Wrapped on CY and Other Manifolds

HORI — Mirror Symmetry & Its Applications

Symplectic ⟷ Analytic/Algebraic

A-branes ⟷ B-branes

GOVINDARAJAN — D-branes & vector bundles on CY manifolds — the "helix"

DOUGLAS — D-branes on CY manifolds

Good source of $d=4$ $N=1$ models — B branes

Kontsevich derived categories — topological D-branes

More structure than K theory; powerful methods

MAJUMDER — Non BPS D-Branes on CY Orbifold

Track down lines of marginal stability
by looking for tachyon modes in
various open strings. Identify phases.

(D7) <u>Brane Worlds and Large</u>

<u>Extra Dimensions</u>

ANTONIADIS   String Physics at Low Energies

   Type I realization of low scale string models

   Alternative approach based on NS5 in type II

IBANEZ   Intersecting Brane Worlds

   e.g.   D4's on $T^2 \times \mathbb{R}^4/\mathbb{Z}_N$

   Multiple crossings → multiple families

   No susy or unification; possible tachyon problems
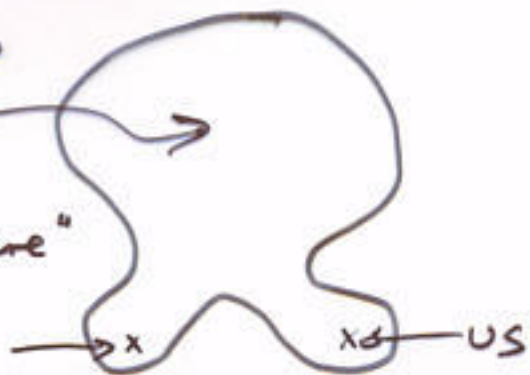
KACHRU & SILVERSTEIN   Tunneling Mediated

Susy Breaking; MultiBrane Constructions & ...

   F theory CY_4 with $N \gg 1$ D3-branes

   in two clusters

Bulk of CY
~ "Planck brane"

Hidden sector ——→ x   x ——US
with SUSY

CONCLUSION

- LOTS OF VERY INTERESTING RESULTS

- NO DRAMATIC BREAKTHROUGHS
  (AS FAR AS I COULD TELL)

- THE BIG UNSOLVED PROBLEMS,
  LISTED BY GROSS AT STRINGS 2000,
  ARE STILL UNSOLVED.

- APOLOGIES TO ALL SPEAKERS,
  WHOSE CONTRIBUTIONS WERE
  OMITTED OR MISREPRESENTED
  IN THIS PRESENTATION.

MANY THANKS TO:

ATISH DABHOLKAR

SUNIL MUKHI

SPENTA WADIA

+ •••

I hope to see all of you
at STRINGS 2002 in July 2002
in CAMBRIDGE, ENGLAND.