Strings 2011, Uppsala

Summary Talk*

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* Title not changed from the original

Outline

- Thanks
- General observations
- Survey of topics* **
- Last minute jokes

* apologies for not summarizing the gong show

** apologies for my limited understanding and choice of topics to emphasize

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- I thank everyone who made the conference run so smoothly.

Observations

Several people encouraged me to work out whether the average age of speakers at the Strings meetings is increasing. I was too lazy to do this computation, but I did look at the number of speakers at this meeting who are ``young'' meaning they received their Ph.D after 2000.

2/6 review talks and 11/28 regular talks were by young speakers. These were also some of the clearest and most interesting talks.

Where are the Strings?

In one sense there has been little string theory at this meeting.

Our view of what string theory is has increased dramatically over the last 16 years: String theory includes branes. String theory is a large N limit of gauge theory.

From this broader viewpoint it is more accurate to say that there has been more of a focus on branes (D3 for N=4 SYM and M5 for (2,0)) than strings and that the study of gravity in AdS/CFT is a low-energy approximation to the string theory we really need to solve.

Triumph of hard work and conservative approaches.

We sometimes think that hard problems require fundamentally new approaches, but in some cases they require difficult, technical work.

Understanding the $N^{3/2}$ behavior of the # of dof of N M2-branes is a nice example of this. It could have required new, exotic structures in 3d QFT (e.g. 3-algebras) but instead it required reformulation of these theories in more standard language, new progress in localization and the application of one to the other.

The love affair between math and physics has turned from a fling into a serious, committed relationship.

Evidently this is not possible without string theory.

It is remarkable how many recent developments in mathematics intersect so closely with developments in the study of amplitudes, black holes, susy gauge theories and so on. These include quantum dilogarithms, mock theta functions, cluster algebras, mixed Tata motives...

This is a part of what is usually called string theory that follows its own internal logic rather than focusing on experiment or proofs, but nonetheless is a rich source of ideas and nontrivial results and motivates new results in both physics and mathematics (quantum computing, enumerative geometry, etc. etc.)

The ``physical'' side of string theory has moved in the direction of AdS/CFT and applications to QCD, dynamics of gauge theory, Condensed Matter and Fluid Dynamics as well the study of Cosmology/Inflation.

Is string theory unification dead?

no he's not dead, he's, he's restin'! -Monty Python

Unlike the parrot in the sketch, I think this is actually true of string unification, but a return to its former vigor is going to require either data from the LHC or dramatic breakthroughs in our understanding of string vacua, or both.

Let me move on to a summary of the material discussed at this meeting.

The summary speaker faces the daunting task of organizing 5 long days of talks. We had an opening talk, 6 hour long reviews, 28 regular talks, and 15(?) gong show talks. We can organize these as follows:

talk classification

- Length (dG)
- Number of Slides (cM)
- Degree of Difficulty (специальная функция)
- Number of Exclamation Points (nV)
- Clarity (pE)

Survey of Topics*

*Unlike several other speakers I will not obey the rules of Swedish neutrality and will instead say what I think.

Scattering Amplitudes

(Beisert, Elvang, Green, Johansson, Volovich)

The rapid progress of the last few years continues unabated with new results, new techniques, and more hints of deep and surprising mathematical structures.

On the math side we heard about connections between amplitudes and geometry and even more remarkable simplifications through the application of "Goncharov" beyond the already remarkable simplifications.

It seems clear that a reformulation of perturbation theory is underway, at least in special QFTs, but the final formulation is not yet known. In the meantime, as has happened in the past, the new techniques are incorporated into practical calculations required for the understanding of QCD background effects.

We heard about new developments in N=8 supergravity using the remarkable relation between N=8 amplitudes and the square of N=4 amplitudes as well as the full analysis of E7 symmetry

Is N=8 a finite theory of quantum gravity? Our standards should be no less strict than those of the Catholic church. The canonization procedure for sainthood requires martyrdom or a miracle for beatification and then a second miracle for canonization and official declaration of sainthood.

It was previously thought that N=8 had qualified for beatification through the miracle of the lower loops, but it turns out that it was not a miracle, but instead a consequence of symmetry. Now with an improved understanding of counterterms a new miracle is needed at 7 loops and probably an infinite number of miracles for all $L>7$. This seems unlikely, but remains an open problem.

The study of amplitudes in N=4 SYM is part of a very ambitious attempt to solve the planar limit for all values of the 't Hooft coupling by combining perturbation theory, AdS/CFT, integrability, new symmetries and perhaps a few lucky guesses. This would be a remarkable achievement which we may be lucky to hear about in some future Strings meeting.

Physical Mathematics

(Cecotti, Cheng, Gaiotto, Gukov, Moore, Morozov, Shatashvili, Tsimpis, Witten)

New connections between old subjects, new applications to mathematics. The revival of N=2 theories at the last Strings meeting continues. The (2,0) theory, aka multiple M5-brane theory, continues to intrigue and inspire.

Philosophy: If you see a manifold, wrap a brane on it. If you see a path integral, localize it.

Moonshine: Sporadic groups are being connected to susy and more realistic compactifications. What is going on?

Fock-Goncharov

Framed BPS states

Glueing=Gauging

Motives

Mutation

Khovanov homology

TBA

M24

Defects

Mock modular forms

It's all happening at the zoo, I do believe it, I do believe it's true...

KSWCF

Zagier

Integrability

Categorification

AGT

Noncompact Chern-Simons

BBB Yogi Berra branes

Mutation

Ballad of a Thin Man

You walk into the room
With your pencil in your hand
....
You try so hard
But you don't understand
Just what you'll say
When you get home.

Because something is happening here
But you don't know what it is
Do you, Mister Jones ?

-Bob Dylan

Cosmology/de Sitter

(Grana, Greene, Linde, Maldacena, McAllister, Shiu)

Inflation and the observed accelerating expansion of the universe make it clear we need to understand cosmological solutions, particularly de Sitter space.

The ghosts of conformal gravity were made somewhat less scary, at least at the classical level, by relating solutions of conformal gravity to those of regular gravity.

Construction of meta-stable solutions in string theory. Do they survive backreaction in IIB? It is subtle.

Search for minimal dS solution without all the bells and whistles of KKLT. It is hard.

Landscape/multiverse skeptics may take some hope from these results, but it seems too early to know for sure.

String theory and inflation: Inflation probes Planck scale physics and hence is a natural place to apply the ideas of string theory. But the current constructions are extremely complicated and not all are sensitive to the UV completion (at least statistically).

Other models with large field values are, and we heard about the development of tools to compare new data with string/sugra inspired inflation models.

With multiple vacua as in flux compactifications one can also tunnel from one configuration to the other and we heard how one studies tunneling and the role of warping.

SM and BSM

(Wilczek, Zwirner)

The LHC is exceeding the expected luminosity and a light Higgs in the 114-158 GeV window should appear by 2011 or 2012 at the latest!

Prospects for low-energy susy are dimmer in a statistical sense, but the jury is still out. Something unexpected would be delightful. It's exciting and perhaps a little nerve wracking waiting to see what the LHC will find.

We heard about the problems of the SM and some not implausible forms of old/new physics: grand unification, susy, axions. It is good to be reminded of these deep puzzles in the SM, and the fact that not all of them can be explained by anthropic arguments. Strange as it seems, we seem to be have a much easier time understanding nontrivial dynamics that we do the values of the couplings in the Standard Model.

Aspects of SUSY theories

(Gaiotto, Gukov, Marino,Moore,Pestun, Seiberg)

In addition to the mathy applications of susy gauge theory we heard about susy on spheres as a means to discover new observeables, gain new insight into dynamics, and test dualities. The formalism of supergravity auxiliary fields can be used to unify the treatment of a variety of special cases. We also heard about the resurgence of localization, not only in math but as a tool for understanding susy in more physical situations.

Black Holes

(Sachdev, Sen)

The understanding of BH entropy is one of the triumphs of string theory and has been checked and developed in great detail using dualities and a sophisticated combination and comparison of worldsheet and spacetime techniques. It also reveals remarkable mathematical structures associated to the counting and properties of 1/2 and 1/4 BPS states.

We heard about more subtle tests of state counting away from the large charge limit involving the sign of the index and logarithmic corrections to the entropy. Again there is spectacular agreement. Whatever else it may or may not be, string theory is a theory of quantum gravity which can explain the structure of susy black holes in exquisite detail.

Future directions: Localization in sugra, N=2 theories, non-susy BH ?

Topics recognizable to a pre 1998 string theorist

(Grana, Greene, Hull, Linde, McAllister, Shiu Tsimpis, Wilczek, Zwirner)

Of course many problems from earlier phases of string theory remain and are worthy of attention. We heard about the study of more general string compactifications and further developments of the "doubled" formalism with manifest T-duality.

Moduli stabilization continues to be a central problem in applications of string theory, whether in unified models or string cosmology Some progress is being made. It would be great to have simpler models. Do we need new ideas or a tour de force of technical analysis?

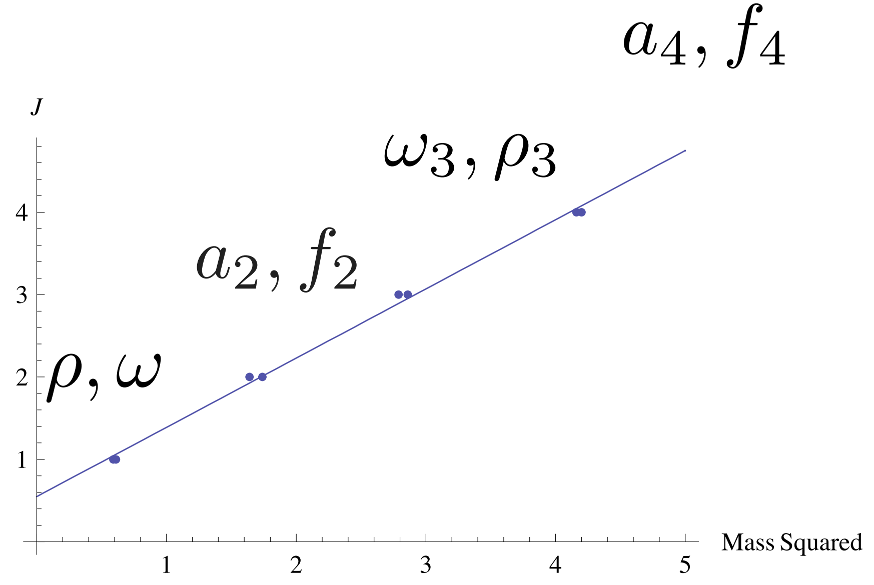
Gauge/Gravity duality and applications

(Gopakumar, Grana, Klose, Marino, Minwalla, Oz, Pestun, Sachdev, Takayanagi, Verlinde)

The range of applications has increased dramatically in the last few years, particularly in CMT.

Study of quantum critical points, computation of transport coefficients $\sigma, \tau_{eq}, \eta/s, \cdots$ attempts to move beyond CFT (quantum compressible matter, non Fermi liquids, application of ABJM!). Good prospects for confrontation with experiment. Testing BH physics in the lab!

We shouldn't forget about the origins of string theory as one of the applications of gauge/gravity duality, one that undoubtedly requires a better understanding of string theory in curved backgrounds, backreaction, inclusion of higher spin fields etc.



We can expect to obtain a qualitative understanding of various phenomena, similar to our understanding of confinement and chiral symmetry breaking in QCD. As in QCD, there is generically no separation of scales between gravity and string theory (gap in spectrum of anomalous dimensions) so quantitative understanding in principle requires going beyond gravitational theories. Of course sometimes we are lucky and find better agreement that we might expect as in the epsilon expansion

As an example of going beyond the gravity approximation we heard about advances in the computation of 3pt functions using semiclassical techniques in AdS/CFT for massive string modes.

We also heard about recent developments in the elegant application of AdS/CFT to the computation of entanglement entropy with applications in CM and quantum computing. This also makes predictions for lattice gauge theory which have been checked numerically. A nice “experimental” test of AdS/CFT.

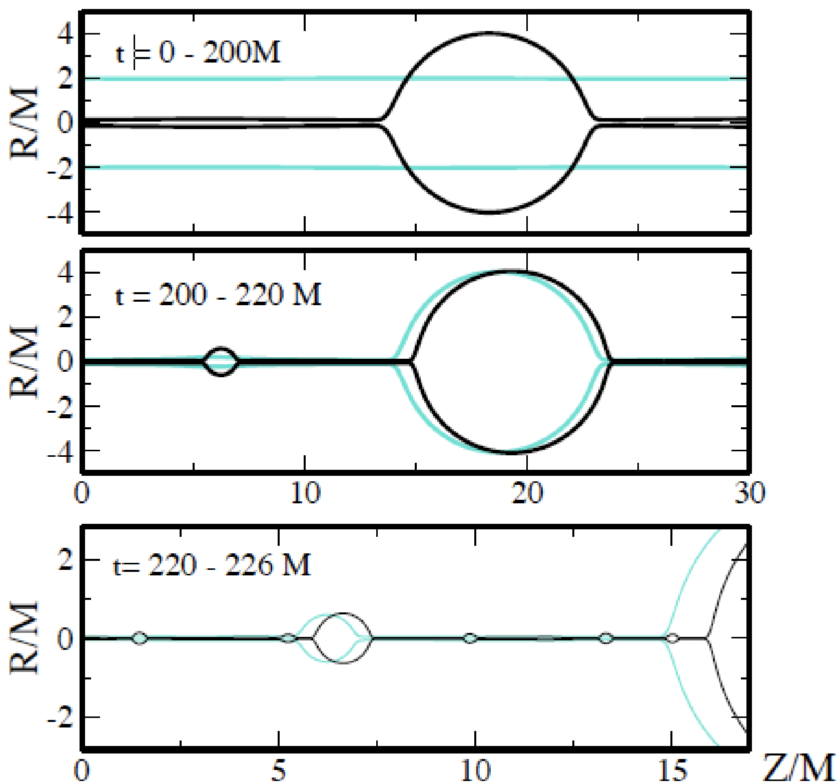
How general is gauge/gravity duality?

There are general arguments for a holographic description of gravity and many signs of such a general structure in string theory (e.g. connections between open and closed string theories) and many reasons to think of spacetime as arising from a deeper substructure. We have specific examples of these phenomena (AdS/CFT, Matrix theory) but a more general understanding is a challenging problem. We heard some ideas about what such an understanding might involve using analogies with Matrix theory.

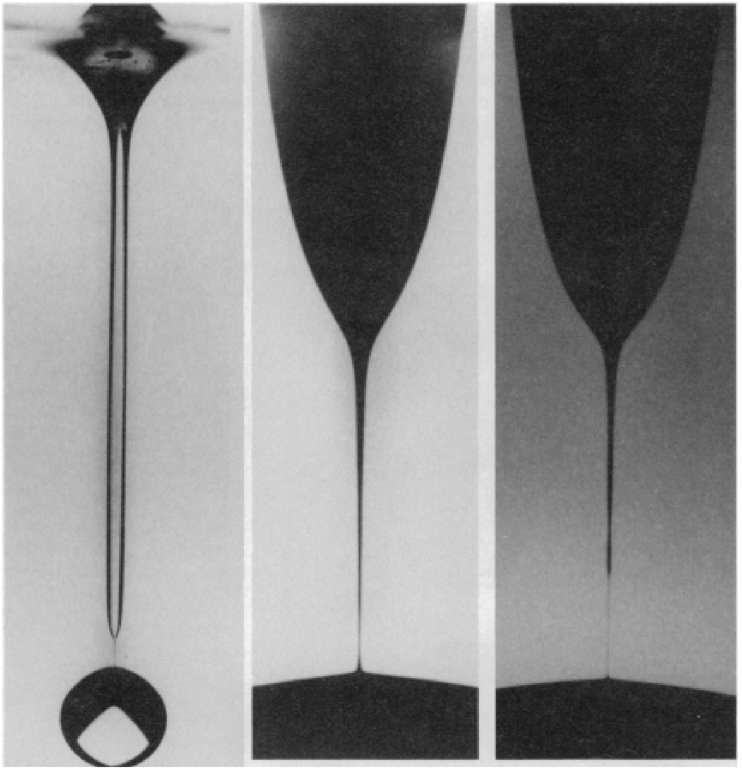
Fluid/gravity duality

The old membrane paradigm suggested a connection between gravity and hydro but with unphysical aspects such as a negative bulk viscosity. BH in AdS/CFT give a consistent framework which generalizes this paradigm and leads to a more direct connection between gravity and (relativistic) hydrodynamics.

Fluids with anomalous currents lead to new terms in hydrodynamics omitted in standard textbook formulations, and general equations for superfluid hydrodynamics were derived. There are potentially new interesting effects in the presence of parity violation. Experimental realization? Constraints on higher derivative terms in gravity?



Lehner & Pretorious study of GL instability



Nagel et. al. drop pinch off

I’m happy to take questions

I wish I had an answer to that because I'm tired of answering that question.

Yogi Berra

If you ask me anything I don't know, I'm not going to answer.

Yogi Berra

THE END