Curriculum Vitae
Horatiu Stefan Nastase

Address:
Instituto de Fisica Teorica,
UNESP- Universidade Estadual Paulista,
R. Dr. Bento Teobaldo Ferraz 271 - Bl. II,
Barra Funda, Sao Paulo, SP 01140-070, Brazil
e-mail: nastase@ift.unesp.br
tel: +55 (11) 3393 7813 (office)

Personal data:
Citizenship: Romanian
Birth date: March 25, 1972
Marital status: Single

Education:

- PhD in Physics, 1996−2000. C. N. Yang Institute for Theoretical Physics, S.U.N.Y. Stony Brook (Now: Stony Brook University),

  Advisor: Prof. Peter van Nieuwenhuizen

  PhD in May 2000, with thesis "Connections between supergravity and gauge theory from supersymmetry and string theory"

- 1994-1996 Niels Bohr Institute, Copenhagen, Denmark, exchange student (1994-1995)/ research (1995-1996).

  Advisor: Prof. Poul Olesen

- 1990-1995 Licentiate's in Physics (5 year degree), Physics Dept., Bucharest University. Last year at Niels Bohr Institute for thesis work.

  Thesis title: 'The notion of particle and spacetime geometry in superstring theories'

- 1986-1990 'Nicolae Balcescu High School for Physics and Mathematics', Bucharest, Romania

Professional employment

- Researcher III (permanent position roughly equivalent to Assistant Professor level), Jan.6 2010-now, IFT-UNESP, Sao Paulo, Brazil

- Assistant Professor of Physics (tenure-track) Nov. 2006- December 31, 2009; Global Edge Institute, Tokyo Institute of Technology

- Assistant Research Professor of Physics (long term postdoc): Sept.2003-Sept. 2006; Brown University
- Postdoctoral Research Associate: 2002-2003; Brown University

- Member (Postdoctoral Research Associate): 2000-2002; Institute for Advanced Study, Princeton.

- Research Assistant: 1997-2000, S.U.N.Y. Stony Brook

- Teaching Assistant: S.U.N.Y. Stony Brook

  - Fall 1996 Semester. Undergraduate introductory course in Physics: teaching lab and grading.
  - Fall 1998 Semester: (for completion of PhD requirements) Quantum Mechanics, Assistant to Prof. C.N. Yang

Teaching:

- IFT: graduate course on AdS/CFT, jointly with Nathan Berkovits.

- TITECH and Tokyo Metropolitan University:

  graduate student intensive course on AdS/CFT.

- Brown University:

  Graduate student reading courses: General Relativity; Black holes and Supergravity. Physics 4 (electromagnetism, optics, introduction to quantum and atomic theory; for science majors outside physics, predominantly pre-med), Summer 2004 and 2005, Brown University. Physics 4 Course Manager, Spring 2005.

- Stony Brook University: TA for pre-med Physics (Fall 1996) and TA for Quantum Mechanics (Fall 1998).

Grants

- Start-up grant for Global Edge Institute, 2006-2008

- KAKENHI (Japanese government) competitive grant, 2008-2010

Postdoctoral Researchers supervised (hired from my grant)

- Dumitru Astefanesei

- Suguru Dobashi

Academic honors and prizes:

-2000 Max Dresden Prize for the best theoretical thesis in the Physics Department of S.U.N.Y. Stony Brook

-1995 Graduated first in my year (out of approx. 300 students) at the Physics Dept., Bucharest University (average 9.95 out of 10)

-1995 Scholarship from Niels Bohr Institute for research (1995/1996)

-1994 Söros Foundation Scholarship for 1994/1995 thesis study at NBI (won in department-wide competition at Bucharest University)

-1990 Second Prize at the International Physics Olympiad in Groningen, Netherlands (approx. 150 High School students from over 30 countries)

Review work

- Reviewer for: Journal of High Energy Physics; Physical Review D; Nuclear Physics B; Physical Review Letters; Classical and Quantum Gravity, Progress of Theoretical Physics, Journal of Physics A.

- Grant reviewer: NSF reviewer (USA; 4 grant proposals reviewed), FONDECYT reviewer (Chile; 2 grant proposal reviewed); FAPESP reviewer (Brazil, 2 grant proposals reviewed); NRF reviewer (South Africa; 1 grant proposal reviewed)

- Member of selection panel- peer reviewing the "Young researchers competition in honor of John Archibald Wheeler", January 2002

- External committee member for MSc. defense: Jelena Smolic, University of Witwatersrand, South Africa; committee member for MSc. defense: Gustavo Machado Monteiro, IFT-UNESP, Brazil.

Professional organizations

- Brazilian Society of Physics (Sociedade Brasileira de Fisica)

Conference organizing

- Organizer for the "Applications of gauge-gravity duality" workshop, Stellenbosch IAS, South Africa, 8-12 December 2008.

**Summary of citations for my papers
from SLAC SPIRES (as of July 8, 2010):**

- 47 papers (46 eligible)

- Total number of citations: 2524

- Renowned papers (500+ cites): 1 (B.M.N.paper)

- Very well-known papers (100+ cites): 2

- Well known papers (50+ cites): 7

- Known papers (10-49 cites): 21

- Less known papers (1-9 cites): 12

- Unknown papers (0 citations): 3

The paper with D. Berenstein and J. Maldacena (B.M.N.) has a total of 1198 citations: 239th most cited High Energy Physics (both theoretical and experimental) paper of all time (since the citation counting began).

Most important research accomplishments

- The year 2002 paper with D. Berenstein and J. Maldacena started the string theory research area known as the "pp wave correspondence". We showed that by taking a certain limit of the AdS/CFT correspondence, we can obtain string theory states (not just gravity) on the gravitational side of AdS/CFT, corresponding to large charge operators on the CFT side. The limit on the gravitational side is the Penrose limit, or pp wave limit, of a curved spacetime. The "pp wave correspondence" in turn was the precursor to the popular description of spin chains from field theory via AdS/CFT, giving a connection of string theory and condensed matter theory.

- The 2 year 1999 papers with D. Vaman and P. van Nieuwenhuizen were the first time that a full consistent nonlinear ansatz for Kaluza-Klein reduction (consistent truncation to the supergravity multiplet) of maximal supergravity on a nontrivial compact space (in this case, S_4) was constructed. Previous work of de Wit and Nicolai for maximal supergravity on S_7 contained some unsolved problems.

- My year 2005 paper "The RHIC fireball as a dual black hole" was the first time that the RHIC fireball was described as dual to a black hole living in the infrared (IR) of the gravity dual of QCD, an area of intense current research. In my model, an actual QCD gravity dual is assumed to exist, unlike currently popular models which focus on "fireballs" in $\mathcal{N} = 4$ Super Yang-Mills (dual to AdS space), as a model for the RHIC fireball.

- My year 1998 paper with G. Chalmers, K. Schalm and R. Siebelink was among the first to directly test the AdS/CFT correspondence, specifically by a calculation of 3-point functions of R-current correlators in $\mathcal{N} = 4$ Super Yang-Mills, in momentum space.

Publication record:

To be published in journal

1. *Asadig Mohammed, Jeff Murugan and Horatiu Nastase*, 'Looking for a Matrix model of ABJM,' to be published in **Phys. Rev. D**, arXiv:1003.2599 [hep-th]

Journal publications

2. *H. Nastase and C. Papageorgakis*, 'Bifundamental fuzzy 2-sphere and fuzzy Killing spinors,' **SIGMA** 6 (2010) 058, 28 pages, and arXiv:1003.5590 [math-ph]

3. *H. Nastase and C. Papageorgakis*, 'Fuzzy Killing spinors and supersymmetric D4 action on the fuzzy 2-sphere from the ABJM model,' **JHEP** 12 (2009) 049 and arXiv:0908.3263 [hep-th].

4. *R. C. Brower, H. Nastase, H. J. Schnitzer and C.-I Tan*, 'Analyticity for Multi-Regge Limits of the Bern-Dixon-Smirnov Amplitudes,' **Nucl. Phys. B** 822 (2009) 301 and arXiv:0809.1632 [hep-th].

5. *H. Nastase, C. Papageorgakis and S. Ramgoolam*, 'The fuzzy S^2 structure of M2-M5 systems in ABJM membrane theories,' **JHEP** 0905 123 (2009) and arXiv:0903.3966 [hep-th]

6. *K. Ito, H. Nastase, K. Iwasaki*, 'Gluon scattering in $\mathcal{N} = 4$ Super Yang-Mills at finite temperature,' **AIP Conf. Proc.** 1078 (2009) 474.

7. *P. G. O. Freund and H. Nastase*, 'Diffractive Vector Meson Photoproduction from Dual String Theory,' **Phys. Rev. D** 79 (2009) 086012 and arXiv:0809.1277 [hep-th]

8. *R. C. Brower, H. Nastase, H. J. Schnitzer and C.-I Tan*, 'Implications of multi-Regge limits for the Bern-Dixon-Smirnov conjecture,' **Nucl. Phys. B** 814 (2009) 293 and arXiv:0801.3891 [hep-th]

9. *S. G. Naculich, H. Nastase and H. J. Schnitzer*, 'Subleading-color contributions to gluon-gluon scattering in N=4 SYM theory and relations to N=8 supergravity,' **JHEP** 11 (2008) 018 and arXiv:0809.0376 [hep-th]

10. *H. Nastase*, 'AdS-CFT and the RHIC fireball,' arXiv:0805.3579 [hep-th], **Progr. Theor. Phys. Suppl.** 174 (2008) 274

11. *S. G. Naculich, H. Nastase and H. J. Schnitzer*, 'Two-loop graviton scattering relation and IR behavior in N=8 supergravity,' **Nucl. Phys. B** 805 (2008) 40 and arXiv:0805.2347 [hep-th]

12. *K. Ito, H. Nastase, K. Iwasaki,* 'Gluon scattering in $\mathcal{N} = 4$ Super Yang-Mills at finite temperature,' **Prog. Theor. Phys.** 120 (2008) 99 and arXiv:0711.3532 [hep-th].

13. *D. Astefanesei, H. Nastase, H. Yavartanoo, S. Yun,*
'Moduli flow and non-supersymmetric AdS attractors,' **JHEP** 0804 074 (2008) and arXiv:0711.0036 [hep-th]

14. *D. Astefanesei, S. Dobashi, K. Ito and H. Nastase,*
'Comments on gluon 6-point scattering amplitudes in N=4 SYM at strong coupling,' **JHEP** 0712 (2007) 077 and arXiv:0710.1684 [hep-th]

15. *Kyungsik Kang and Horatiu Nastase*
'High energy QCD from Planckian scattering in AdS and the Froissart bound,' **Phys. Rev. D** 72:106003, 2005 and hep-th/0410173

16. *Kyungsik Kang and Horatiu Nastase*
'Heisenberg saturation of the Froissart bound from AdS-CFT,' **Phys. Lett. B** 624:125-134, 2005 hep-th/0501038.

17. *Kyungsik Kang and Horatiu Nastase*
'Planckian scattering effects and black hole production in low M_{Pl} scenarios,' **Phys. Rev. D** 71:124035, 2005 and hep-th/0409099

18. *David Lowe, Horatiu Nastase and Sanjaye Ramgoolam*
'Massive IIA string theory and Matrix theory compactification', **Nucl. Phys. B** 667 (2003) 55, hep-th/0303173

19. *David Berenstein, Juan Maldacena and Horatiu Nastase*
'Strings in flat space and pp waves from N=4 Super Yang-Mills', **AIP Conf. Proc.** 646 (2003) 3

20. *David Berenstein, Juan Maldacena and Horatiu Nastase*
'Strings in flat space and pp waves from N=4 SuperYang-Mills', **JHEP** 0204 (2002) 013, hep-th/0202021

21. *Juan Maldacena, Horatiu Nastase*
'The supergravity dual of a theory with dynamical supersymmetry breaking', **JHEP** 0109 (2001) 024, hep-th/0105049

22. *Horatiu Nastase, Warren Siegel*
'A new AdS/CFT correspondence', **JHEP** 0010:040, 2000, hep-th/0010106

23. *Iosif Bena, Horatiu Nastase and Diana Vaman*
'Propagators for p-forms in AdS(2p+1) and correlation functions in the AdS(7)/(2,0) CFT correspondence' , **Phys. Rev. D** 64:106009, 2001, hep-th/0008239

24. *Horatiu Nastase*

'Connections between supergravity and gauge theory from supersymmetry and string theory', PhD Thesis, UMI-99-74922-mc (microfiche) (2000)

25.*Horatiu Nastase, Diana Vaman*

'On the nonlinear KK reductions on spheres of supergravity theories', **Nucl. Phys. B** 583:211-236, 2000, hep-th/0002028

26.*Horatiu Nastase, Diana Vaman and Peter van Nieuwenhuizen,*

'Consistency of the $AdS_7 \times S_4$ reduction and self-duality in odd dimensions', **Nucl. Phys. B** 581:179-239, 2000, hep-th/9911238

27.*Horatiu Nastase, Diana Vaman and Peter van Nieuwenhuizen,*

'Consistent nonlinear KK truncation of 11-d supergravity on $AdS_7 \times S_4$ and selfduality in odd dimensions', *Phys. Lett. B* 469:96-102, 2000, hep-th/9905075

28.*Gordon Chalmers, Horatiu Nastase, Koenraad Schalm and Ruud Siebelink*, 'R current correlators in N=4 SuperYang-Mills theory from Anti-de Sitter supergravity', **Nucl. Phys. B** 540:247-270, 1999, hep-th/9805105

29.*Horatiu Nastase, Misha A. Stephanov, Peter van Nieuwenhuizen*, 'Topological boundary conditions, the BPS bound, and elimination of ambiguities in the quantum mass of solitons.', **Nucl. Phys. B** 542:471-514, 1999, hep-th/9802074

Published on the electronic archives

30. *H. Nastase*, 'On IR solutions in Horava gravity theories', arXiv:09043604[hep-th]

31. *H. Nastase,*

'Introduction to AdS-CFT,' arXiv:0712.0689 [hep-th]

32. *Horatiu Nastase,*

'D=4 Einstein gravity from higher D CS and BI gravity and an alternative to dimensional reduction,' hep-th/0703034

33. *Horatiu Nastase,*

'A Black hole solution of scalar field theory,' hep-th/0702037.

34. *Horatiu Nastase*

'More on the RHIC fireball and dual black holes,' hep-th/0603176.

35. *Horatiu Nastase*

'Constant H field, cosmology and faster than light solitons,' hep-th/0601182

36. *Horatiu Nastase*

'DBI Skyrmion, high energy (large s) scattering and fireball production,' hep-th/0512171

37. *Horatiu Nastase*

'The RHIC fireball as a dual black hole,' hep-th/0501068.

38. *Horatiu Nastase*

'The soft Pomeron from AdS-CFT,' hep-th/0501039.

39. *Antal Jevicki and Horatiu Nastase*

'Towards S matrices on flat space and pp waves from SYM,' hep-th/0501013.

40. *Horatiu Nastase*

'On fuzzy spheres and (M)atrix actions,' BROWN-HET-1425 and hep-th/0410137

41. *Horatiu Nastase*

'On high energy scattering inside gravitational backgrounds,' BROWN-HET-1424 and hep-th/0410124

42. *Horatiu Nastase*

'Towards a Chern-Simons M theory of $Osp(1|32) \times OSp(1|32)$', hep-th/0306269

43. *Horatiu Nastase*

'On Dp-Dp+4 systems, QCD dual and phenomenology', hep-th/0305069

44. *David Berenstein and Horatiu Nastase*

'On lightcone string field theory from Super Yang-Mills and holography', hep-th/0205048

45. *David Berenstein, Edi Gava, Juan Maldacena, K.S. Narain and Horatiu Nastase*

'Open string on plane waves and their Yang-Mills duals', hep-th/0203249

46. *Horatiu Nastase and Diana Vaman*

'The AdS/CFT correspondence, consistent truncations and gauge invariance', hep-th/0004123

47. *Horatiu Nastase*

A possible solution of the black hole information paradox through quantum gravity unified with other interactions, hep-th/9601042, NBI-HE-96-02.

Webpage with description of my research:
http://www.th.phys.titech.ac.jp/ nastase/public_html/research.html

Invited conference talks

- The fuzzy S^2 structure of M2-M5 systems in ABJM membranes theories, invited talk; also, Summary talk for the conference, "String/M theory workshop", Sungkyunkwan University, Korea, June 2009

- Scattering amplitudes and gauge-gravity dualities I and II, invited lectures, "Applications of gauge-gravity duality" workshop, Stellenbosch IAS, South Africa, December 2008.

- Understanding amplitudes in $\mathcal{N} = 4$ Super Yang-Mills and $\mathcal{N} = 8$ supergravity, "Summer Institute 2008" workshop, invited talk, Fuji-Yoshida, Japan, August 2008

- A black hole solution of scalar field theory and the RHIC fireball, "Gravitational Thermodynamics and the Quantum Nature of Space Time," conference, Edinburgh University, UK, June 2008

- AdS-CFT and the RHIC fireball, "Fundamental problems in hot and dense QCD" conference, invited review talk, Kyoto, March 2008

- Relations between string theory and general relativity, South African Relativity Society meeting, keynote talk, February 2008, Cape Town

- The RHIC fireball as a black hole in gravity duals of QCD, JPS Fall 2007 meeting plenary talk, Hokkaido University, Sapporo

- High energy QCD collisions at RHIC and the LHC from dual black hole production, Conference invited talk: Exploring QCD: Deconfinement, Extreme Environments & Holography, Isaac Newton Institute, Cambridge University, UK, August 2007

- High energy QCD and the Froissart bound from AdS scattering, Miami 2004 (Key Biscayne and Corral Gables), December 2004

- High energy scattering and black hole production, PASCOS 2004 (Northeastern University) plenary talk, August 2004

Public talks

- Nuclear forces from gravitational theory: a string theory connection, public lecture (physics and non-physics audience), University of London, Queen Mary College, UK, July 2007.

- String theory and gravity in extra dimensions, Complexity and dimensionality workshop, March 2004, Brown Univ.

Colloquia

- Perspectives in High Energy Physics: Potential impact of the LHC, Physics Department, Oslo University, Norway, April 2010

- Using string theory to understand particle collisions, IFT-UNESP, Brazil, March 2010

- Using string theory to understand particle collisions, Physics Department Colloquium, Tokyo Institute of Technology, Japan, October 2008.

- Particle physics, black holes and string theory, Brown University Physics Department, January 2006.

- String theory from gauge theory and vvs., Texas A& M Physics Department, April 2004

Invited research talks

- Fuzzy spheres and M2-M5 systems in ABJM, given at
  -IMPU, University of Tokyo, November 2009
  -Rikkyo University, November 2009
  -Tokyo University, Komaba, December 2009

- Fuzzy spheres and M2-M5 systems in BLG/ABJM theories, Albert Einstein Institute, Potsdam, Germany, July 2009

- 1/N corrections to gluon scattering in $\mathcal{N} = 4$ SYM and relation to $\mathcal{N} = 8$ supergravity, Queen Mary College, University of London, UK, May 2009

- Fuzzy spheres and BLG/ABJM theories, Chalmers University, Goteborg, Sweden, May 2009

- Understanding amplitudes in $\mathcal{N} = 4$ Super Yang-Mills and $\mathcal{N} = 8$ supergravity, Queen Mary College, University of London, UK, July 2008.

- Black Hole Production in Gravity Duals and Experimental Implications for QCD and RHIC I and II, invited lectures at University of London, Queen Mary College, UK, July 2007.

- Black hole production in A-S shockwave scattering and applications for QCD and RHIC via AdS-CFT, joint seminar of relativity groups at Tokyo U., Hongo; Waseda U., TITECH, January 2007

- Black hole production in gravity duals and experimental implications for QCD and RHIC, given at

  -Tokyo Institute of Technology, December 2006

  -Tokyo University, Hongo, December 2006

  -Tokyo University, Komaba, February 2007

  -Kyoto University, February 2007

  -KEK, April 2007

  -RIKEN, June 2007

- Black hole production, the Froissart bound, the soft Pomeron and the RHIC fireball from AdS-CFT, given at

  -Chicago University, January 2005

  -YITP, SUNY Stony Brook, January 2005

  -Nuclear Theory group, Brookhaven National Lab, January 2005

  -Rochester University, February 2005

-Princeton University, February 2005

-Brown University, February 2005

-MIT, February 2005

-KITP, UC Santa Barbara, February 2005

-Rutgers University, March 2005

-University if Wisconsin, Madison, March 2005

-University of Michigan, Ann Arbor, March 2005

-Yale University, September 2005

- High energy scattering and black hole production, Brown University, September 2004

- String theory on pp waves from SYM, Rochester U, April 2004

- On Dp-D(p+4) systems, QCD dual and phenomenology, given at

  -Brown University, September 2003

  -Harvard University, October 2003

  -University of New Hampshire, November 2003

- Towards a Chern-Simons M theory of $OSp(1|32) \times OSp(1|32)$, given at

  -Brown University, June 2003

  -SUNY Stony Brook, October 2003

- Massive IIA string theory and Matrix theory compactification, given at

  -U Wisconsin at Madison, February 2004

  -Brown University, April 2003

  -MIT, April 2003

- Matrix models and pp waves, Duke University, October 2002

- String interactions and holography in pp wave backgrounds, Brown University, June 2002

- String and matrices in flat space and pp waves from supersymmetric gauge theories, given at:

  -ITP, University of California at Santa Barbara, March 2002

  -Caltech-USC Institute for Theoretical Physics, March 2002

  -State University of New York at Stony Brook, March 2002

  -Rockefeller University, March 2002

  -Ohio State University, April 2002

  -Rutgers University, April 2002

- A 3d gauge theory with dynamical susy breaking and its supergravity dual, Princeton University, June 2001

- Consistent nonlinear KK reductions on spheres and the AdS-CFT correspondence, given at:

  -University of Michigan at Ann Arbor, December 1999

  -Syracuse University, January 2000

  -Brown University, January 2000

Detailed description of research accomplishments

Experimental predictions of string theory via QCD: the Froissart bound, the soft Pomeron and the RHIC fireball. We found that black hole production in the string theory gravity dual is mapped to the "soft Pomeron" behaviour of the total QCD cross section at large s. Heisenberg's pion model for the saturation of the Froissart bound is mapped exactly onto the gravity dual picture, which is effectively 4 dimensional. I predict the "soft Pomeron" power law $\sigma_{tot} \sim s^\epsilon$ and test that it matches current experiments. The power law counts the extra dimensions in the gravity dual and how many of them are in AdS.

The produced black hole in the Froissart regime is mapped to a pion field "soliton", which is the fireball observed at RHIC. From this picture the general properties of the RHIC fireball are derived. The soliton dual to the black hole can be obtained in a simple scalar field model, and has an apparent singularity equivalent to the black hole horizon. Skyrmion solutions

stand for hadrons, whereas the boosted solutions collide and form black hole like-solitons.

Recently, we have found that the same dual black hole physics, described by the Pomeron, describes vector meson photoproduction, and we have obtained a prediction for a thermal distribution of vector meson cross sections, which is satisfied within experimental limits.

String theory in flat space and pp waves from Super Yang Mills; lightcone string field theory; Matrix models (based on B.M.N. paper) We found that the string spectrum in flat space and on paralel plane gravitational waves arises from the large N 't Hooft limit of $\mathcal{N} = 4$ Super Yang-Mills. This was the first concrete realization of the old idea of 't Hooft that Yang-Mills theories in the large N limit should become string theories. We have found that a class of operators with large R charge has a dual description in terms of strings.

We have also shown that an $\mathcal{N} = 2$ orientifold of the $\mathcal{N} = 4$ SYM has a dual description in terms of string theory with open strings interacting with the closed strings. We have started to analyze the interactions (string field theory) of the (closed and open) strings from the point of view of field theory. This has the potential of rigorously (and nonperturbatively) defining the string theory in certain backgrounds, a fact which is still lacking in string theory. We have also found a model describing (M)atrix theory on a pp wave background, that has many possible implications for (M)atrix theory. It admits fuzzy sphere solutions. The possibility of general fuzzy (noncommutative) spheres as (M)atrix theory solutions was also investigated.

Fuzzy spheres and ABJM theory

ABJM have constructed a 2+1 dimensional Chern-Simons type action for multiple (N) M2 branes in 11 dimensions, based on previous work of Bagger, Lambert and Gustavsson, motivated by fuzzy funnel BPS equations. We have found that the fuzzy funnel and fuzzy sphere solutions of ABJM theory and mass-deformed ABJM theory respectively, are not as fuzzy 3-sphere/funnel, but rather fuzzy 2-sphere/funnel, despite the original motivation. A new description of the fuzzy 2-sphere results from our calculation, and a single D4 brane emerges in the limit of large N. The fuzzy 2-sphere description is completely equivalent to the usual one in terms of the $SU(2)$ algebra, and it is given in terms of fuzzy versions of Killing spinors.

Towards a Matrix model for ABJM

We have analyzed the possibility that we can understand the large N $SU(N) \times SU(N)$ CS gauge theory of ABJM as a new kind of Matrix model

for M theory. We proposed that the vortex solution of the 3d CS theory acts as a spacetime supergraviton, and that other solutions can be interpreted as other types of branes in the spacetime theory. The results are inconclusive, since scattering of supergravitons and scattering of vortices seem to give different results, though possibly due to different applicability.

Clarification of Horava gravity I have shown that Horava gravity, a theory of gravity modified in the UV, where it does not have general coordinate invariance, reproduces Einstein gravity in the IR on physical scales only if one adds an independent cosmological constant. I have also found the Schwarzschild-like solution in this case.

Gluon scattering in $\mathcal{N} = 4$ Super Yang Mills

The Alday-Maldacena proposal for a gravity dual of n-gluon scattering amplitudes in $\mathcal{N} = 4$ Super Yang-Mills is defined by string worldsheets in an Anti de Sitter space, bounded by a lightlike polygon. The strong coupling result for $n = 4, 5$ matches a conjecture of Bern, Dixon and Smirnov, but it was known to be fixed by conformal invariance. We have calculated the dual of a certain piece of the n=6 result. We have also found from Regge behaviour that the BDS conjecture satisfies all constraints, yet is not necessarily complete for $n \geq 6$. We also showed that at finite temperature one can still calculate gluon amplitudes, but the result is not dual to the Wilson loop anymore.

We have analyzed the Regge limits of gluon scattering in $\mathcal{N} = 4$ Super Yang-Mills, and have found that the Bern-Dixon-Smirnov ansatz is consistent with the expected results. We have found however that there are subtleties for the helicity pole and triple Regge limits of $\mathcal{N} = 4$ Super Yang-Mills, for instance that the naive generalized unitarity relation needs to be modified.

We have also analyzed subleading N corrections to the gluon scattering, and found that a surprising relation to the graviton scattering in $\mathcal{N} = 8$ supergravity exists at one and two loop level, but fails to extend in a simple way to higher loops.

Graviton scattering in $\mathcal{N} = 8$ Supergravity

Graviton scattering amplitudes in $\mathcal{N} = 8$ Supergravity are known to be related to the gluon amplitudes in $\mathcal{N} = 4$ Super Yang-Mills by the KLT relations, which make it easier to calculate one if one knows the ingredients for calculating the other. A relation between the two-loop and one-loop 4-point amplitudes in $\mathcal{N} = 4$ Super Yang-Mills by Anastasiou, Bern, Dixon and Kosower (ABDK) has led to developments culminating in the BDS conjecture for the full amplitudes in SYM. We have found that a similar relation to the

ABDK one is valid in $\mathcal{N} = 8$ supergravity, hopefully to lead to a better understanding of supergravity amplitudes.

A black hole solution of scalar field theory

I have shown that there is a scalar field theory that admits a black-hole like solution, with a thermal horizon of fixed finite temperature, that traps information (it takes an infinite time for information to escape the horizon). This is a toy model for the RHIC fireball, whose dual is a black hole. Moreover, the scalar field theory is unique.

Noncommutative theory, cosmology and faster than light solitons

I found that a constant H field antisymmetric tensor, H_{123}, even if it is whithin cosmological bounds, can still have an effect on particle physics, by creating noncommutative solitons (with noncommutativity $\theta^{ij} = \epsilon^{ijk}x^k$) that move faster than the speed of light. They are the analogs of the Hashimoto-Itzhaki faster than light solitons for constant noncommutativity. The noncommutative background doesn't break spontaneously more Lorentz invariance than the cosmological FRW ansatz already does.

S matrices on pp waves from SYM We have made a proposal of how to derive S matrices on pp waves from SYM correlators. S matrices on nontrivial spaces are interesting on their own, but this proposal could also lead to a nonperturbative definition of the string theory in the pp wave background via SYM.

Planckian scattering effects, black hole production and high energy QCD We have analyzed the cross-section for black hole production in low M_{Pl} scenarios via scattering of Aichelburg-Sexl-type shockwaves in the corresponding gravitational backgrounds, following earlier work of Eardley and Giddings. We have found that the geometric cross-section is still a good approximation. We then applied this scattering methods via AdS-CFT duality, a la Polchinski-Strassler to calculate effects of high energy scattering in QCD. We have proven more rigorously the appearence of the Froissart bound, as suggested originally by Giddings. The formalism for high energy gravitational scattering in AdS-like backgrounds was also extended to more general backgrounds.

Towards a Chern-Simons M theory of $OSp(1|32) \times OSp(1|32)$ I have suggested that one could have a Chern-Simons supergravity in 11 dimensions (a Chern-Simons gauge theory of the supergroup $OSp(1|32) \times OSp(1|32)$) as an extension of the usual 11d Cremmer-Julia-Sherk supergravity. I have explored the possible connection to M theory. The Chern-Simons theory

has a cosmological constant already in 11d which could explain the observed cosmological constant, giving an extra justification for the theory, together with interesting cosmologies.

Towards a holographic dual of QCD and braneworld models I have identified a way to keep only fundamental fermions and no adjoint fermions in the gravity-gauge holography. A holographic dual of a nonsupersymmetric theory with fundamental fermions and no adjoint fermions was found, and a candidate QCD dual was described (although the gravity solution was not found). This construction offers new ideas for braneworld constructions of the Standard Model.

Matrix model for massive IIA string theory Matrix theory gives a nonperturbative definition of string/M theory in certain backgrounds. The prototype is flat space M theory in discrete lightcone quantization, put forward by BFSS. All string theories in flat space were described in this way (together with some compactifications and some nontrivial spaces), except massive IIA. We found that the Matrix model of massive IIA is a D3 brane theory with spacetime noncommutativity, interesting in its own right. Massive IIA is also a laboratory to analyze outstanding problems like de Sitter space in string theory.

Gravity dual of 3d N=1 Super Yang-Mills We analyzed various phenomena in a nonconformal gauge theory using gravity duals. The theory, arising via NS5 branes wrapped on a three-sphere, exhibits dynamical susy breaking, confinement and mass gap in various regimes. It gives a handle on the study of nonperturbative phenomena in more realistic models.

A 'new' AdS−CFT correspondence We gave a new type of relation between a string theory in AdS_5 and a field theory in 4d. The Feynman diagrams of the field theory correspond to discretized worldsheets of the string. In the bosonic case, we obtain a ϕ^4 field theory, in the supersymmetric case we obtain a nonlocal N=4 superfield action for a YM-like theory.

The AdS−CFT correspondence, consistent truncations and gauge invariance; correlators involving p-forms in AdS−CFT The existence of consistent truncations implies that we have to use a modified prescription for the AdS-CFT correspondence. We gave evidence for it, and then computed certain p-form correlators in the AdS-CFT correspondence as a first step to definitely prove the new prescription.

Consistent nonlinear KK truncation of 11-d supergravity on $AdS_7 \times S_4$ and selfduality in odd dimensions - We were the first to find the explicit ansatz and to show consistency of the Kaluza-Klein reduction

(truncation to the supergravity multiplet) of the usual 11d supergravity on a nontrivial compact space, namely S_4. The existence of a consistent truncation was used to eliminate an ambiguity in the formulation of the AdS-CFT correspondence. We also found a mechanism for obtaining 'selfduality in odd dimensions' by KK reduction from higher dimensions.

R current correlators in N=4 SuperYang-Mills theory from Anti-de Sitter supergravity - We used Maldacena's (recently conjectured) AdS-CFT correspondence, in the formulation of Gubser-Klebanov-Polyakov-Witten, to compute three point functions of R current operators in the $SU(N_C)$ SuperYang-Mills theory at large N_C and large 't Hooft coupling, $g^2 N_C$. This provided a nontrivial check of the correspondence, since on the SuperYang-Mills side we could compute them also. The calculation was done in momentum space, as opposed to other x-space calculations in the literature.

Topological boundary conditions, the BPS bound, and elimination of ambiguities in the quantum mass of solitons We computed the quantum corrections to the mass of a two dimensional soliton ('the kink'). We used these methods for an N=1 supersymmetric model to see whether the Bogomoln'yi bound for the soliton mass, saturated at the classical level, remains saturated at the quantum level. The methods were tested for an N=2 model, where we did not find any corrections, in agreement with general ideas. A new physical principle (the use of the 'topological boundary conditions') was used.

Professional references

-Prof. Howard J. Schnitzer, The Martin A. Fisher School of Physics, Brandeis University, Waltham, MA-02454, USA

email: schnitzer@brandeis.edu

phone: +1 (781) 736 2882

-Prof. Peter van Nieuwenhuizen, YITP, S.U.N.Y. Stony Brook, NY-11974-3840, USA

email:vannieu@insti.physics.sunysb.edu

phone: +1 (631) 632 7972

-Prof. Martin Roček, YITP, S.U.N.Y. Stony Brook, NY-11974-3840, USA

email: rocek@insti.physics.sunysb.edu

phone: +1 (631) 632 7965

-Prof. Antal Jevicki, Physics Dept., Box 1843, Brown University, Providence RI-02912, USA

email: antal@het.brown.edu
phone: +1 (401) 863 2624