

AMS/IP

**Studies in  
Advanced  
Mathematics**

S.-T. Yau, Series Editor

**Advances in  
String Theory**

**The First Sowers Workshop  
in Theoretical Physics**

**Eric Sharpe  
Arthur Greenspoon  
Editors**



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Volume 44

## Advances in String Theory

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## Preface

Over the last decade string theory has, despite its purely theoretical content, started to make a strong impact on many areas of physics: high energy and hadronic physics, gravitation and cosmology, mathematical physics and even condensed matter physics. The impact has been through many major conceptual and methodological developments in quantum field theory in the past fifteen years. The ideas of duality, holography, extra dimensions, conformal field theory, gauge theory/gravity correspondence, *etc.* have excited the imagination of many theoretical and experimental physicists in these diverse fields of physics. In addition, string theory has exerted a dramatic influence on developments in contemporary mathematics, ranging from mirror symmetry and enumerative geometry in algebraic geometry to Seiberg-Witten theory in four-manifolds.

Nevertheless, despite these advances the fundamentals of string theory are still largely unknown. Thus it seemed appropriate to have a gathering of younger leading practitioners of various aspects of the field around the common theme: “What is string theory?” This gathering took place at Virginia Tech on May 14–18, 2007. This unique event was made possible by a generous donation from a friend and benefactor of the physics department at Virginia Tech, Mr. Mark Sowers, in whose honor the workshop was named, “The first Sowers workshop in theoretical physics.”

As can be seen from the proceedings the range of topics was very wide, cutting through many aspects of string theory. We thank the contributors for making this volume possible in a timely manner. We also thank the colleagues at the Department of Physics and the College of Science at Virginia Tech for support and help. Most of all, we sincerely thank our donor and our friend Mr. Mark Sowers for making this meeting, and thus this proceedings possible.

We warmly dedicate this volume to Mark Sowers.

The organizers,

D. Minic, E. Sharpe, T. Takeuchi, and A. Yelnikov



## Acknowledgements

This workshop was made possible through a meeting of two worlds: the world of business and the world of science. Mr. Mark Sowers, a highly successful business man, is fascinated by the frontiers of theoretical physics. The organizers, Djordje Minic, Eric Sharpe, Tatsu Takeuchi, and Alexandr Yelnikov, had a vision: To bring together some of the brightest young minds in string theory to discuss their most recent findings and generate new ideas, in a relaxed and supportive setting. Thanks to Mark Sowers's generous support, the vision became reality, and the first Sowers Theoretical Physics Workshop "What is String Theory?" was held at Virginia Tech in May 2007. The College of Science and the Department of Physics gratefully acknowledge both worlds: We thank Mark Sowers most warmly for his generosity, and the organizers for running a successful and enjoyable workshop. We hope that these proceedings will help continue the discussions.

Lay Nam Chang, Dean, College of Science  
Beate Schmittmann, Chair, Department of Physics

## Schedule of Talks

### Monday May 14, 2007

9:00 – 9:30	Welcome and opening remarks	
9:30 – 10:30	V. Balasubramanian	Emergence of spacetime and gravitational entropy, I
11:00 – 12:00	Ori Ganor	Puff field theory
2:00 – 3:00	Rob Leigh	Mottness and strong coupling
3:30 – 4:30	Anastasios Petkou	Towards the holography of higher spins: the paradigm of conformal holography in AdS <sub>4</sub>
4:30 – 5:30	Sumit Das	Null singularities and their gauge theory duals

### Tuesday May 15, 2007

9:30 – 10:30	Keith Dienes	Statistical results from the heterotic landscape
11:00 – 12:00	Scott Thomas	Landscape naturalness
2:00 – 3:00	Nemanja Kaloper	Charting the landscape of modified gravity
3:30 – 4:30	Dan Kabat	Local bulk physics in AdS/CFT
4:30 – 5:30	Li-Sheng Tseng	Heterotic geometry and fluxes

### Wednesday May 16, 2007

9:30 – 10:30	Djordje Minic	On the spectrum of pure QCD in 3 and 4d
11:00 – 12:00	Jan de Boer	Emergence of spacetime and gravitational entropy, II
Afternoon	Free	
Evening	Public lecture, presented by Vijay Balasubramanian	

**Thursday May 17, 2007**

9:30 – 10:30	A. Tomasiello	Progress on the geometry of supersymmetric string vacua
11:00 – 12:00	Finn Larsen	Precision entropy of black holes
2:00 – 3:00	Simeon Hellerman	Cosmological unification of string theories
3:30 – 4:30	Eric Sharpe	Recent developments in heterotic compactifications
4:30 – 5:30	Volker Braun	Worldsheet instantons and torsion curves

**Friday May 18, 2007**

9:30 – 10:30	Savdeep Sethi	Aspects of hypermultiplets
11:00 – 12:00	Kentaro Hori	Phases of $N=2$ theories in 1+1 dimensions with boundary
2:00 – 3:00	E. Diaconescu	Supersymmetry breaking in IIA vacua
3:30 – 4:30	Petr Horava	Quantum gravity at a Lifshitz point

## List of Participants

<b>Name</b>	<b>Institution</b>
Zach Alsgaard	Virginia Tech
Vijay Balasubramanian*	University of Pennsylvania
Ed Barnes	University of Virginia
Aaron Bergman	Texas A&M
Jan de Boer*	University of Amsterdam
Volker Braun*	University of Pennsylvania
Zachary Burell	Auburn University
Jonathan Cates	Virginia Tech
Sumit Das*	University of Kentucky
Joshua Davis	UCLA
Emanuel Diaconescu*	Rutgers University
Keith Dienes*	University of Arizona
Josh Erlich	College of William and Mary
John Ficenec	Virginia Tech
Ori Ganor*	University of California, Berkeley
Elizabeth Gichana	Radford University
Eric Gimon	University of California, Berkeley
Peter Haskell	Virginia Tech
Simeon Hellerman*	Institute for Advanced Study, Princeton
Petr Horava*	University of California, Berkeley
Kentaro Hori*	University of Toronto
Vishnu Jejjala	University of Durham, UK
Dan Kabat*	Columbia University
Nemanja Kaloper*	University of California, Davis
Michael Kavic	Virginia Tech
Cynthia Keeler	University of California, Berkeley
Finn Larsen*	University of Michigan
Tommy Levi	New York University (NYU)
Rob Leigh*	University of Illinois, Urbana-Champaign
Bob McNeese	Brown University
Ilarion Melnikov	University of Chicago
Djordje Minic*	Virginia Tech

<b>Name</b>	<b>Institution</b>
Tetsuro Mizutani	Virginia Tech
Uma Murthy	Virginia Tech
Phil Nelson	Virginia Tech
Anastasios Peppas	Blinn College
Anastasios Petkou*	University of Crete
Michel Pleimling	Virginia Tech
Alexey Pronin	Virginia Tech
Matt Raum	Virginia Tech
Savdeep Sethi*	University of Chicago
Eric Sharpe*	University of Utah, Virginia Tech
Christopher Snell	Virginia Tech
Tatsu Takeuchi	Virginia Tech
Uwe Tauber	Virginia Tech
Scott Thomas*	Rutgers University
Alessandro Tomasiello*	Stanford University, SLAC
Li-Sheng Tseng*	Harvard University
Oleksandr Yelnykov	Virginia Tech

(\* = speaker)

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Over the past decade string theory has had an increasing impact on many areas of physics: high energy and hadronic physics, gravitation and cosmology, mathematical physics and even condensed matter physics. The impact has been through many major conceptual and methodological developments in quantum field theory in the past fifteen years. In addition, string theory has exerted a dramatic influence on developments in contemporary mathematics, including Gromov–Witten theory, mirror symmetry in complex and symplectic geometry, and important ramifications in enumerative geometry.

This volume is derived from a conference of younger leading practitioners around the common theme: “What is string theory?” The talks covered major current topics, both mathematical and physical, related to string theory.

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