MATTHEW HEADRICK

Title Assistant Professor of Physics, Brandeis University

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Research interests String theory and related areas of quantum field theory, general relativity, geometry, and quantum information theory

Employment & education

Brandeis University, 2008–present
Assistant Professor, Martin Fisher School of Physics
Undergraduate courses taught: "Mathematical physics", "Quantum theory I"
Graduate course taught: "Quantum mechanics I"
Visitor, Harvard University (fall 2009)

Stanford University, 2006–2008
Postdoctoral Scholar, Stanford Institute for Theoretical Physics

Massachusetts Institute of Technology, 2003–2006
Pappalardo Fellow, Center for Theoretical Physics

Tata Institute of Fundamental Research, 2002–2003
Visiting Fellow, Department of Theoretical Physics

Harvard University, 1996–2002
Ph.D. in Physics (March 2003)
Thesis: "Noncommutative solitons and closed string tachyons"
Advisor: S. Minwalla
M.A. in Physics (June 1998)
Teaching fellow: "Topics in string theory", "Mechanics and special relativity", "Electricity, magnetism, and waves"; Certificate of Distinction in Teaching; Harold T. White Prize for Excellence in the Teaching of Physics (2000–2002)
Research assistant for Profs. J. Maldacena and S. Minwalla (1999–2002)
Exchange scholar, Princeton University (spring 1999)
National Science Foundation Graduate Research Fellow (1996–1999)

Lycée d'Etat de Ndendé, Gabon, 1994–1996
Peace Corps Volunteer
Secondary-school mathematics, physics, and chemistry teacher

Princeton University, 1990–1994
A.B. in Physics with Highest Honors (June 1994)
Inducted in Phi Beta Kappa and Sigma Xi (May 1994)
Kusaka Memorial Prize in Physics for senior thesis (May 1994)
Kusaka Memorial Prize in Physics for junior paper (May 1993)
Exchange scholar, Ecole Normale Supérieure de Lyon (fall 1992)
Research assistant for Prof. J.R. Gott III, Department of Astrophysics (spring 1992)

Schools attended

Prospects in Theoretical Physics: Applications of String Theory, Institute for Advanced Study (July 2006)

Modern Trends in String Theory II, Porto, Portugal (June 2004)

IPM String School, Anzali, Iran (September–October 2003)

NATO ASI: Progress in String, Field, and Particle Theory, Institut d'Etudes Scientifiques de Cargèse (June–July 2002)

School on Quantum Gravity, Centro de Estudios Cientificos, Valdivia (January 2002)

TASI 99: Strings, Branes, and Gravity (June 1999)

Other employment

Santa Fe Institute, summer 1993
Research assistant for Dr. M. Mitchell and Prof. J. Crutchfield

NSF Geometry Center, University of Minnesota, 1990–1991
Script-writer and animator for the educational movie *Outside In* (First Place, International Congress of Mathematicians VideoMath Contest, 1998)

University of Chicago, 1989–1990
Research assistant for Prof. R. Haselkorn, Department of Molecular Genetics and Cell Biology
First Prize, Westinghouse Science Talent Search (March 1990)

Research funding

National Science Foundation Early Career Development (CAREER) Award, "Holography, Quantum Information, and Elliptic Relativity," 2011–present

Department of Energy Office of High-Energy Physics grant DE-FG02-92ER40706, 2010–present

Professional activities

Referee for the journals *JHEP*, *Comm. Math. Phys.*, *Class. Quant. Grav.*, *Phys. Lett. B*, *Phys. Rev. Let.*, *Phys. Rev.* D, and *New Jour. Phys.*

Grant and fellowship reviewer for National Science Foundation and UK Royal Society

Consultant in the preparation of the second edition of *Advanced Quantum Mechanics* by F. Dyson, transcribed by D. Derbes (World Scientific, to appear)

Co-organizer of the workshop "Quantum information in quantum gravity and condensed-matter physics," Aspen Center for Physics, May–June 2011

Author of `diffgeo.m`, a *Mathematica* package that assists in computations in differential geometry and general relativity. Co-author of `grassmann.m`, a package for working with Grassmann variables

Member of TheoryNet, a network connecting theoretical physicists to high-school science teachers, with period presentations to science classrooms

Technical reviewer, *String Theory for Dummies* by A. Z. Jones (Wiley Publishing, 2009)

Invited talks

"Quantum information and entanglement in holographic theories"
University of Massachusetts, Amherst (October 2011)
University of Texas, Austin (October 2011)
"Quantum information in quantum gravity and condensed-matter physics" workshop, Aspen Center for Physics (May 2011)
Massachusetts Institute of Technology (April 2011)
University of Michigan (January 2011)
University of New Hampshire (December 2010)
"Applications of AdS/CFT to condensed matter systems" conference, Galileo Galilei Institute, Florence (November 2010)
SUNY Stony Brook (October 2010)
McGill University (September 2010)
Massachusetts Institute of Technology (June 2010)
Korea Institute for Advanced Study (May 2010)

"Gravity, entropy, and entanglement"
MIT Pappalardo Symposium (October 2010)
Brandeis University Physics Colloquium (October 2010)

"Calabi-Yau metrics for dummies"
Institute for the Physics and Mathematics of the Universe, Tokyo University (June 2010)
Massachusetts Institute of Technology (March 2010)
Durham University (November 2009)
Dublin Institute for Advanced Studies (October 2009)
Tata Institute of Fundamental Research (October 2009)
Harvard University (September 2009)

"Progress on numerical Calabi-Yau metrics"
Quantum Theory and Symmetries conference, University of Kentucky (July 2009)

"Tachyon actions in string theory: a no-go theorem"
"Fundamental aspects of superstring theory" program, Kavli Institute for Theoretical Physics (May 2009)
Massachusetts Institute of Technology (December 2008)
Brown University (October 2008)

"New approaches to numerical Calabi-Yau metrics"
Boston University Geometry Seminar (April 2009)

"Ricci flow, and some applications"
Everytopic Seminar, Brandeis University Mathematics Department (November 2008)

"Ricci flow, Kähler-Einstein manifolds, and numerical geometry"
University of California, Santa Cruz, mathematics graduate colloquium (May 2008)

"Hedgehog black holes and the deconfinement transition"
PIMS Pacific Northwest String Seminar, University of British Columbia (April 2008)
University of California, Davis (November 2007)
University of Oxford Mathematical Institute (November 2007)
"Strong fields, integrability, and strings" program, Isaac Newton Institute (November 2007)
Queen Mary, University of London (November 2007)
Tata Institute of Fundamental Research (October 2007)
Imperial College London (June 2007)

"The uses of Ricci flow"
University of Texas, Austin (March 2007)
Stanford Linear Accelerator Center (March 2007)
Brandeis University (February 2007)
University of California, Berkeley (January 2007)

"Scale transformations and the dynamics of string theory"
Brandeis University Physics Colloquium (February 2007)

"Ricci flow and black holes"
Massachusetts Institute of Technology (October 2006)
Southern California Strings Seminar, University of Southern California (September 2006)
University of California, Santa Barbara (September 2006)
"Recent advances in black holes in string theory" workshop, Aspen Center for Physics (August 2006)
University of Chicago (August 2006)
Brown University (April 2006)

"On time dependence in string theory"
Cambridge University (May 2006)
Johns Hopkins University (April 2006)
University of Kentucky (March 2006)

"The shape of the extra dimensions"
University of Wisconsin, Milwaukee Physics Colloquium (April 2006)
Massachusetts Institute of Technology Pappalardo Symposium (May 2005)

"A string theorist's adventures in numerical relativity"
University of Kentucky Center for Computational Sciences (March 2006)

"Closed string tachyon dynamics"
Perimeter Institute (December 2005)

"Numerical Ricci-flat metrics on K3"

Biséminaire ENS/IHP de Physique et de Mathématiques, Paris (July 2005)
Zhejiang University Center of Mathematical Sciences (April 2005)
Brandeis University Math/CS/Physics Everyperson Seminar (February 2005)
Harish-Chandra Research Institute (December 2004)

"Closed string tachyon condensation on C/Z_n"
Modern Trends in String Theory II, Porto (June 2004)
Harvard University (March 2004)
University of Texas, Austin (February 2004)

"Progress in closed string tachyon condensation"
IPM String Workshop, Anzali, Iran (October 2003)
Tata Institute of Fundamental Research Theoretical Physics Colloquium (September 2003)
Harish-Chandra Research Institute (September 2003)

"Spacetime energy decreases under world-sheet RG flow"
University of Chicago (December 2002)
Perimeter Institute (November 2002)

"String interactions from perturbative Yang-Mills theory"
Stanford University (October 2002)

"String interactions in the BMN correspondence"
Massachusetts Institute of Technology (October 2002)
University of Pennsylvania (September 2002)

"Time travel in general relativity"
MIT Media Lab (March 1997)

Publications

P. Hayden, M. Headrick, and A. Maloney, "Holographic mutual information is monogamous," 1107.2940 [hep-th]

H. Ebrahim and M. Headrick, "Instantaneous thermalization in holographic plasmas," 1010.5443 [hep-th]

M. Headrick, "Entanglement Rényi entropies in holographic theories," 1006.0047 [hep-th], *Phys. Rev.* D82: 126010 (2010)

M. Headrick, "Progress on numerical Calabi-Yau metrics," to be published in *Proceedings of Quantum Theory and Symmetries 6*

M. Headrick and A. Nassar, "Energy functionals for Calabi-Yau metrics," 0908.2635 [hep-th], accepted for publication in *Adv. Theor. Math. Phys.*

M. Headrick, S. Kitchen, and T. Wiseman, "A new approach to static numerical relativity, and its application to Kaluza-Klein black holes," 0812.4408 [gr-qc], *Class. Quant. Grav.* 27: 035002 (2010) [chosen by the editors as an IOPselect article and included in the annual highlights collection for 2009–2010]

M. Headrick, "A solution manual for Polchinski's *String Theory*," 0812.4408 [hep-th]

M. Headrick, "A note on tachyon actions in string theory," 0810.2809 [hep-th], *Phys. Rev.* D79: 046009 (2009)

M. Headrick, "Hedgehog black holes and the Polyakov loop at strong coupling," 0712.4155 [hep-th], *Phys. Rev.* D77: 105017 (2008)

M. Headrick and T. Wiseman, "Numerical Kähler-Ricci soliton on the second del Pezzo," 0706.2329 [math.DG]

M. Headrick and T. Takayanagi, "A holographic proof of the strong subadditivity of entanglement entropy," 0704.3719 [hep-th], *Phys. Rev.* D76: 106013 (2007)

C. Doran, M. Headrick, C.P. Herzog, J. Kantor, and T. Wiseman, "Numerical Kähler-Einstein metric on the third del Pezzo," hep-th/0703057, *Comm. Math. Phys.* 282, 357 (2008)

M. Headrick and T. Wiseman, "Ricci flow and black holes," hep-th/0606086, *Class. Quant. Grav.* 23: 6683 (2006)

D.Z. Freedman, M. Headrick, and A. Lawrence, "On closed string tachyon dynamics," hep-th/0510126, *Phys. Rev.* D73: 066015 (2006)

M. Headrick and T. Wiseman, "Numerical Ricci-flat metrics on K3," hep-th/0506129, *Class. Quant. Grav.* 22: 4931 (2005) [included in the annual highlights collection for 2005–2006]

M. Headrick and J. Raeymaekers, "The large N limit of C/Z_N and supergravity," hep-th/0411148, *JHEP* 0502:054 (2005)

M. Headrick, S. Minwalla, and T. Takayanagi, "Closed string tachyon condensation: An overview," hep-th/0405064, *Class. Quant. Grav.* 21: S1539 (2004)

M. Headrick, "Decay of C/Z_n: exact supergravity solutions," hep-th/0312213, *JHEP* 0403:025 (2004)

M. Gutperle, M. Headrick, S. Minwalla, and V. Schomerus, "Spacetime energy decreases under world-sheet RG flow," hep-th/0211063, *JHEP* 0301:073 (2003)

N.R. Constable, D.Z. Freedman, M. Headrick, and S. Minwalla, "Operator mixing and the BMN correspondence," hep-th/0209002, *JHEP* 0210:068 (2002)

N.R. Constable, D.Z. Freedman, M. Headrick, S. Minwalla, L. Motl, A. Postnikov, and W. Skiba, "PP-wave string interactions from perturbative Yang-Mills theory," hep-th/0205089, *JHEP* 0207:017 (2002)

J.R. David, M. Gutperle, M. Headrick, and S. Minwalla, "Tachyon condensation on twisted circles," hep-th/0111212, *JHEP* 0202:041 (2002)

R. Gopakumar, M. Headrick, and M. Spradlin, "On noncommutative multi-solitons," hep-th/0103256, *Comm. Math. Phys.* 233: 355 (2003)

R. Gopakumar, M. Headrick, and M. Spradlin, "Noncommutative solitons I," *Proceedings of Strings 2001, Mumbai*

M. Headrick and J.R. Gott III, "(2+1)-dimensional spacetimes containing closed timelike curves," *Phys. Rev.* D50: 7244 (1994)