

Avery E. Broderick

Curriculum Vitae

Avery Earl Broderick

Canadian Institute for Theoretical Astrophysics
60 St. George Street, Toronto, ON M5S 3H8, Canada
(416) 978-6857; aeb@cita.utoronto.ca
www.cita.utoronto.ca/~aeb

Personal

b. Sonoma, CA, March 6, 1977; U.S. Citizen

Education

California Institute of Technology, Pasadena CA

Ph.D. 2004, Physics

Thesis: *Radiative Transfer in Accreting Environments*

Advisor: Professor Roger Blandford

State University of New York at Stony Brook, Stony Brook NY

B.S. 1999, Physics & Mathematics, *Cum Laude with honors in Physics*

Employment

Canadian Institute for Theoretical Astrophysics, Toronto ON

Senior Research Associate, 2007–

Harvard-Smithsonian Center for Astrophysics, Cambridge MA

Institute for Theory and Computation Postdoctoral Fellow, 2004–2007

California Institute of Technology, Pasadena CA

Graduate Research and Teaching Assistant, 1999–2004

State University of New York at Stony Brook, Stony Brook NY

Undergraduate Research Assistant in the Nuclear Theory Group, 1997–1999

State University of New York at Stony Brook, Stony Brook NY

Undergraduate Research Assistant in the Nuclear Structure Laboratory, 1996–1997

Awards & Honors

CITA Senior Research Associate, 2007–

Lindheimer Fellowship (Northwestern), 2007 (declined)

Zwicky Fellowship (ETH), 2007 (declined)

Certificate of Distinction in Teaching, 2007 (Derek Bok Center, Harvard University)

ITC Fellow (Harvard), 2004–2007

Hubble Fellow, 2004 (declined)

Lyman Spitzer Jr. Fellowship (Princeton), 2004 (declined)

CITA Postdoctoral Fellowship, 2004 (declined)

TAC Fellowship (Berkeley), 2004 (declined)

ARCS Fellow, 2002–2004

RTN Exchange student, 2003, 2004

Theoretical Astrophysics in Southern California Outstanding Graduate Student Speaker 2001

Undergraduate Award for Research Excellence, 1999

Membership in $\Sigma\Pi\Sigma$, 1998

REU Participant, 1997,1998

Grants

Co-I (w/ A. Loeb) on Grant AST0907890: “Testing Accretion Physics and Strong-Field Gravity by Imaging Accreting Black Holes,” (\$540,000, 2009–2012)

Co-I (w/ R.D. Blandford, J.C. McKinney, S. Akiyama & D. Uzdensky) on Grant AST080029: “Accurate Direct Numerical Simulations of Magnetically-Driven Gamma-Ray Bursts and Supernovae” (8 million CPU-hours on Lonestar & Abe, at Teragrid, 2009-2010)

Professional Societies & Service

Editorial Board Member for *Scientific Reports*, 2011–2013, (A new interdisciplinary journal from the Nature Publishing Group, <http://www.nature.com/srep>)

American Astronomical Society (High Energy Astrophysics Division)

Referee for ApJ, ApJL, Physics Letters B, MNRAS, & Living Reviews

Book Reviewer for Classical & Quantum Gravity

Internal Reviewer for Cambridge University Press

ITC Seminar co-organizer (Harvard-Smithsonian Center for Astrophysics)

CITA-Jamboree organizer, 2008, 2009, 2010 (A day-long mini-conference on research at CITA)

Author for *Scientific American*, December 2009

Press Coverage

Science News (cover story) *Black hole silhouettes* by Charles Petit, 10/2010

Sky & Telescope (website), *How To See a Black Hole*, Ivan Semeniuk, 10/2009

Daily Planet (TV interview), Ivan Semeniuk, 12/2009

New Scientist, *Coming soon: First pictures of a black hole* by Stephen Battersby, 5/2009

New Scientist, *Vanishing matter points to black hole in Milky Way* by David Shiga, 4/2009

Physics Today, *Measuring the black hole at the Milky Way’s center* by Bertram Schwarzschild, 11/2008

Space.com, *Closest Look Yet at Milky Way’s Black Hole* by Clara Moskowitz 9/3/2008

Astronomy.com, *To the edge of a black hole* 9/3/2008

New Scientist, *The true nature of black holes* by Michael D. Lemonick, 10/6/2007

Nature, *Physicists plan search for the known unknowns* by Jenny Hogan, 1/31/2007

Economist, *Weighing the Universe* by Stephen Jeffrey, 1/25/2007

USA TODAY, *Deep inside black holes* by Dan Vergano, 2/26/2006

Space.com, *A Quest to See a Black Hole’s Shadow* by Bjorn Carey 10/11/2005

Popular Articles

Broderick, A.E. & Loeb, A. 2009. “Shedding Light on Darkness: Imaging Black Hole Silhouettes”, *Scientific American*, December, 2009

Teaching Experience

Department of Physics, University of Toronto

Lecturer: PHY 2401S *Cosmology and Black Holes* (with Profs. U.-L. Pen & L. Kauffman)

Department of Astronomy, Harvard University

Teaching Fellow: Astro 193 *Noise & Data Analysis in Astrophysics*, Spring 2007 (Prof. J. Moran)

Teaching Fellow: Astro 218 *Radio Astronomy*, Spring 2006 (Prof. J. Moran)

Teaching Fellow: Science A-47 *Cosmic Connections*, Fall 2005 (Prof. Lars Hernquist)

Department of Physics, Harvard University

Teaching Fellow: Physical Sciences 2 *Sophomore Laboratory*, Fall 2006 (Prof. M. Franklin)

Physics, Mathematics & Astronomy Division, California Institute of Technology

Teaching Assistant: Physics 1c *Freshman Physics*, Spring 2003 (Prof. D. Politzer)
 Teaching Assistant: Physics 1b *Freshman Physics*, Winter 2002 (Prof. D. Politzer)
 Teaching Assistant: Physics 1a *Freshman Physics*, Fall 2002 (Prof. B. McKeown)
 Teaching Assistant: Physics 7 *Sophomore Laboratory*, Spring 2002 (Inst. F. Rice)
 Head Teaching Assistant: Physics 2b *Sophomore Physics*, Winter 2001 (Prof. A. Lange)
 Head Teaching Assistant: Physics 2a *Sophomore Physics*, Fall 2001 (Prof. A. Lange)
 Teaching Assistant: Physics 7 *Sophomore Laboratory*, Spring 2001 (Inst. F. Rice)
 Teaching Assistant: Physics 2b *Sophomore Physics*, Winter 2000 (Prof. F. Harrison)
 Teaching Assistant: Physics 2a *Sophomore Physics*, Fall 2000 (Prof. C. Martin)
 Teaching Assistant: Physics 1c *Sophomore Physics*, Spring 2000 (Prof. A. Lange)
 Teaching Assistant: Physics 2b *Sophomore Physics*, Winter 1999 (Prof. C. Martin)
 Teaching Assistant: Physics 2a *Sophomore Physics*, Fall 1999 (Prof. D. Goodstein)

Mathematics Department, State University of Stony Brook

Teaching Assistant: MAT 123 *Introduction to Calculus*, Spring 1998

Refereed Journal Articles (most recent first)

29. **Broderick, A.E.** & McKinney, J.C. 2010. “Parsec-scale Faraday Rotation Measures from General Relativistic Magnetohydrodynamic Simulations of Active Galactic Nucleus Jets”, *ApJ*, 725, 750
28. **Broderick, A.E.** & Keto, E. 2010. “The Evolution of Cloud Cores and the Formation of Stars”, *ApJ*, 721, 493
27. **Broderick, A.E.** & Blandford, R.D. 2010. “Understanding the Geometry of Astrophysical Magnetic Fields”, *ApJ*, 718, 1085
26. Fish, V.L., Doeleman, S.S., **Broderick, A.E.**, Loeb, A. & Rogers, A.E.E. 2009. “Detecting Changing Polarization Structures in Sagittarius A* with High Frequency VLBI”, *ApJ*, 706, 1353
25. **Broderick, A.E.** & Loeb, A. 2009. “Signatures of Relativistic Helical Motion in the Rotation Measures of Active Galactic Nucleus Jets”, *ApJL*, 703, 104
24. **Broderick, A.E.**, Loeb, A. & Narayan, R. 2009. “The Event Horizon of Sagittarius A*”, *ApJ*, 701, 1357
23. **Broderick, A.E.** & Loeb, A. 2009. “Imaging the Black Hole Silhouette of M87: Implications for Jet Formation and Black Hole Spin”, *ApJ*, 697, 1164
22. **Broderick, A.E.**, Fish, V.L., Doeleman, S.S. & Loeb, A. 2009, “Estimating the Parameters of Sagittarius A*’s Accretion Flow Via Millimeter VLBI”, *ApJ*, 697, 45
21. Doeleman, S.S., Fish, V.L., **Broderick, A.E.**, Loeb, A. & Rogers, A.E.E. 2009. “Detecting Flaring Structure in Sagittarius A* with High-Frequency VLBI”, *ApJ*, 695, 59
20. Fish, V.L., **Broderick, A.E.**, Doeleman, S.S. & Loeb, A. 2008. “Using Millimeter VLBI to Constrain RIAF Models of Sagittarius A*”, *ApJL*, 692, 14
19. **Broderick, A.E.**, Narayan, R., Keto, E. & Lada, C.J. 2008. “The Damping Rates of Embedded Oscillating Starless Cores”, *ApJ*, 682, 1095
18. Reid, Mark J., **Broderick, A.E.**, Loeb, A., Honma, M. & Brunthaler, A. 2008. “Limits on the Position Wander of Sgr A*”, *ApJ*, 682, 1041
17. **Broderick, A.E.** & Narayan, R. 2007. “Magnetic helicity and the relaxation of fossil fields”, *MNRAS*, 383, 943
16. **Broderick, A.E.**, Keto, E., Lada, C.J. & Narayan, R. 2007. “Oscillating Starless cores: The Non-linear Regime”, *ApJ*, 671, 1832

15. **Broderick, A.E.** & Narayan, R. 2007. “Where are all the gravastars? Limits upon the gravastar model from accreting black holes”, *Classical & Quantum Gravity*, 24, 659
14. Keto, E., **Broderick, A.E.**, Lada, C.J. & Narayan, R. 2006. “Oscillations of Starless Cores”, *ApJ*, 652, 1366
13. **Broderick, A.E.** & Rathore, Y. 2006. “A multidimensional, adiabatic hydrodynamics code for studying tidal excitation”, *MNRAS*, 372, 923
12. **Broderick, A.E.** & Loeb, A. 2006. “Imaging optically-thin hotspots near the black hole horizon of Sgr A* at radio and near-infrared wavelengths”, *MNRAS*, 367, 905
11. **Broderick, A.E.** 2006. “Radiative transfer along rays in curved space-times”, *MNRAS*, 366, L10
10. **Broderick, A.E.** & Narayan, R. 2006. “On the Nature of the Dark Mass at the Galactic Center”, *ApJL*, 638, 21
9. **Broderick, A.E.** & Loeb, A. 2006. “Frequency-dependent Shift in the Image Centroid of the Black Hole at the Galactic Center as a Test of General Relativity”, *ApJL*, 636, 109
8. **Broderick, A.E.** & Loeb, A. 2005. “Imaging bright-spots in the accretion flow near the black hole horizon of Sgr A*”, *MNRAS*, 363, 353
7. **Broderick, A.E.** 2005. “Supernovae in helium star–compact object binaries: a possible gamma-ray burst mechanism”, *MNRAS*, 361, 955
6. Rathore, Y., Blandford, R. & **Broderick, A.E.** 2005. “Resonant excitation of white dwarf oscillations in compact binaries –I. The no back reaction approximation”, *MNRAS*, 357, 834
5. **Broderick, A.** & Blandford, R. 2004. “Covariant magnetoionic theory – II. Radiative transfer”, *MNRAS*, 349, 994
4. **Broderick, A.** & Blandford, R. 2003. “Covariant magnetoionic theory – I. Ray propagation”, *MNRAS*, 342, 1280
3. Rathore, Y., **Broderick, A.E.** & Blandford, R. 2003. “A variational formalism for tidal excitation: non-rotating, homentropic stars”, *MNRAS*, 339, 25
2. **Broderick, A.E.**, Prakash, M. & Lattimer, J.M. 2002. “Effects of strong magnetic fields in strange baryonic matter”, *Phys. Lett. B*, 531, 167
1. **Broderick, A.**, Prakash, M. & Lattimer, J.M., 2000. “The Equation of State of Neutron Star Matter in Strong Magnetic Fields”, *ApJ*, 537, 351

Preprints & In Preparation

4. **Broderick, A.E.** 2010. “The Evolution of Electromagnetic Fields in Dynamic Spacetimes”
3. **Broderick, A.E.** & Loeb, A. 2010. “Localizing Sagittarius A* and M87 on Microarcsecond Scales with Millimeter VLBI”
2. **Broderick, A.E.**, Fish, V.L., Doeleman, S.S. & Loeb, “Constraining the Structure of Sagittarius A*’s Accretion Flow with Millimeter-VLBI Closure Phases” (*submitted to ApJL*)
1. **Broderick, A.E.**, Fish, V.L., Doeleman, S.S. & Loeb, A. 2010. “Evidence for Low Black Hole Spin and Physically Motivated Accretion Models from Millimeter VLBI Observations of Sagittarius A*” (*submitted to ApJ*, arXiv:1011.2770)

Posters & Proceedings

8. **Broderick, A.E.** 2009. “Imaging Black Hole Horizons”, CASCA 2009 (Toronto)

7. Fish, V.L., Doeleman, S.S., **Broderick, A.E.**, Loeb, A. & Rogers, A.E.E. 2008. “Detecting Flaring Structures in Sagittarius A* with (Sub)Millimeter VLBI”, XXIX URSI General Assembly (Chicago)
6. **Broderick, A.E.**, McKinney, J. & Morales, M. 2006. “Supernovae in Compact Binaries: A new GRB mechanism”, XXIII Texas Symposium on Relativistic Astrophysics (Melbourne, Australia)
5. **Broderick, A.E.** & Loeb, A. 2006. “Testing General Relativity with High-Resolution Imaging of Sgr A*”, From the Center of the Milky Way to Nearby Low-Luminosity Galactic Nuclei, Journal of Physics: Conference Series ed. R. Schödel, G.C. Bower, M.P. Muno, S. Nayakshin & T. Ott (Philadelphia: Institute of Physics Publishing)
4. **Broderick, A.** & Blandford, R. 2003. “General Relativistic Magnetoionic Theory”, Circular Polarisation From Relativistic Jet Sources, Astrophysics & Space Science ed. R.P. Fender & J.-P. Macquart (Dordrecht: Kluwer Academic Publishers)
3. **Broderick, A.** & Blandford, R. 2002, “General Relativistic Magnetoionic Theory”, ITP Conference on Black Holes: Theory Confronts Reality, Three Years Later (UC Santa Barbara)
2. Blandford, R.D., Agol, E., **Broderick, A.**, Heyl, J., Koopmans, L. & Lee, H.-W. 2001. “Compact Objects and Accretion Disks”, Astrophysical Spectropolarimetry ed. J. Trujillo-Bueno, F. Moreno-Insertis, F. Sanchez (Cambridge: Cambridge University Press)
1. **Broderick, A.** & Blandford, R.D. 2000. “Propagation of Plasma Modes Around a Kerr Black Hole”, AAS Meeting 197

Presented and Upcoming Talks

38. “Probing the Gastronomy of Supermassive Black Holes with High and Ultra-High Resolution Imaging”, Physics & Astronomy Colloquium (University of Waterloo), February 1, 2011 (*Invited*)
37. “The Event Horizon Telescope: Imaging Black Hole Horizons”, Special Seminar (Perimeter Institute), January 31, 2011 (*Invited*)
36. “The Life and Times of Black Holes and Other Stories: Research Topics in Compact Object Astrophysics”, Astrophysics Lunch Talk (University of Pittsburgh), January 24, 2011 (*Invited*)
35. “The Event Horizon Telescope: Imaging Black Hole Horizons”, Physics & Astronomy Colloquium (University of Pittsburgh), January 24, 2011 (*Invited*)
34. “The Hairstyles of Compact Objects”, Theory Meets Data Analysis at Comparable and Extreme Mass Ratios, CAPRA+NRDA Meeting (Perimeter Institute), June 20-26, 2010 (*Invited*)
33. “Measuring the Geometry of AGN Core Magnetic Fields”, Rotation Measure Analysis of Magnetic Fields in and around Radio Galaxies (Riccione, Italy), May 10-14, 2010
32. “Staring into the Abyss: Imaging Black Hole Horizons”, Special SAO Colloquium (CfA), March 8, 2010 (*Invited*)
31. “Staring into the Abyss: Imaging Black Hole Horizons”, Astro Seminar (NYU), February 26, 2010 (*Invited*)
30. “Imaging Black Hole Horizons”, Formation and Evolution of Black Holes, 2010 Winter Conference on Astrophysics (Aspen Center for Physics), February 16, 2010
29. “Nature of the black hole in the center of the Milky Way”, APS Invited Session *Probing strong-field gravity with observations of the galactic center black hole*, (Washington D.C.), February 13, 2010 (*Invited*)
28. “Staring into the Abyss: Imaging Black Hole Horizons”, Joint Astrophysics Colloquium (McGill University), February 2, 2010 (*Invited*)

27. “To the Edge and Back: Directly Imaging the Horizon of a Black Hole”, Royal Astronomical Society of Canada, October 28, 2009 (*Invited*)
26. “Staring Into the Abyss: Directly Imaging Black Hole Event Horizons”, Physics Colloquium (University of Guelph), October 13, 2009 (*Invited*)
25. “Imaging Nearby Black Holes: Providing a window on accretion, jet formation and general relativity”, Astronomy Colloquium (Columbia University), April 8, 2009 (*Invited*)
24. “Directly Imaging the Horizons of Black Holes”, Astrophysics Colloquium (MIT), January 29, 2009 (*Invited*)
23. “A New Window on Jet Formation: Millimeter & Submillimeter VLBI”, 213th AAS Meeting (Long Beach), January 6, 2009
22. “The Nature of Sagittarius A*”, AAS Special Session *Getting to the Event Horizon: Sgr A** (Long Beach), January 5, 2009 (*Invited*)
21. “Imaging Black Hole Horizons”, Special Colloquium (Northwestern University), November 20, 2008 (*Invited*)
20. “Imaging Horizons”, Astrophysics with Radio and Gravitational-Wave Observatories (Charlottesville), November 8, 2008 (*Invited*)
19. “On the Horizon: Imaging Nearby Black Holes”, ACKS Seminar (Kavli Institute for Particle Astrophysics and Cosmology, Stanford), August 14, 2008 (*Invited*)
18. “On the Horizon: Imaging Nearby Black Holes”, INPP+API Seminar (Ohio University), May 13, 2008 (*Invited*)
17. “At the horizon: Imaging black holes and testing general relativity”, Astronomy Colloquium (University of Illinois), February 15, 2008 (*Invited*)
16. “At the horizon: Imaging black holes and testing general relativity”, Astronomy Colloquium (University of Chicago), February 13, 2008 (*Invited*)
15. “Testing the Kerr Metric: Confronting Strong Field Relativity with Observations”, Physics Colloquium (Georgia Tech), March 26, 2007 (*Invited*)
14. “Imaging the Central Black Hole in the Milky Way”, Rethinking Gravity: From the Planck scale to the size of the Universe (Tuscon), January 22, 2007 (*Invited*)
13. “Microarcsecond imaging of Sgr A*: A way to test the Kerr metric”, Special Theoretical Astrophysics Seminar (Northwestern University), January 18, 2007 (*Invited*)
12. “Microarcsecond imaging of Sgr A*: A way to test the Kerr metric”, CITA Seminar (Canadian Institute for Theoretical Astrophysics), January 16, 2007 (*Invited*)
11. “Testing the Kerr Metric with Micro-Arcsecond Imaging of Sgr A*”, XXIII Texas Symposium on Relativistic Astrophysics (Melbourne), December 11-15, 2006
10. “Microarcsecond Imaging of Sgr A* and Testing General Relativity”, RAL Seminar (UC Berkeley), October 16, 2006 (*Invited*)
9. “Radio Imaging of Sgr A*”, New Results on the Galactic Centre (XXVI IAU General Assembly, Prague), August 21, 2006 (*Invited*)
8. “Testing General Relativity with Images of Sgr A*”, The History of Nuclear Black Holes in Galaxies (Cambridge), May 15, 2006 (*Invited*)
7. “The possibility of testing general relativity with high-resolution imaging of Sgr A*”, Galactic Center Workshop 2006 (Bad Honnef), April 22, 2006
6. “Circular Polarisation from Tangled Magnetic Fields”, Institute of Astronomy Seminar (Cambridge University), August 11, 2004 (*Invited*)

5. "Polarization Effects Near Black Holes", X-ray Polarimetry Workshop (SLAC), February 9, 2004 (*Invited*)
4. "Covariant Magnetoionic Theory (CP Production in BH Accretion Flows)", TAC Seminar (UC Berkeley), January 28, 2004 (*Invited*)
3. "Circular Polarization in Black Hole Accretion Flows (The Role of Refraction)", AAS Meeting (Atlanta), January 7, 2004
2. "General Relativistic Magnetoionic Theory", Circular Polarisation from Relativistic Jet Sources (University of Amsterdam), July 19, 2002 (*Invited*)
1. "General Relativistic Magnetoionic Theory and Low Luminosity AGN", Theoretical Astrophysics in Southern California (California Institute of Technology), October 26, 2001