

Alex Lupsasca

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Department of Physics & Astronomy
and Department of Mathematics
Vanderbilt University
Nashville, Tennessee

RESEARCH INTERESTS

Black hole imaging, electromagnetic observations, and (very-long-baseline) radio interferometry
General relativity, gravitational lensing, photon rings, and black hole ringdown
Plasma magnetospheres, force-free electrodynamics, and electromagnetic spin-energy extraction
Relativistic astrophysics of compact objects: black holes, neutron stars, and pulsars
Extremal black holes: theoretical properties, emergent symmetries, and observational signatures

PROFESSIONAL EXPERIENCE

Project Scientist for the **Black Hole Explorer (BHEX)** space mission (2024–)
Assistant Professor of Physics & Mathematics, Vanderbilt University (2022–)
Associate Research Scholar, Princeton Gravity Initiative (2020–2022)
Junior Fellow, Harvard Society of Fellows (2017–2020)

EDUCATION

Ph.D., Physics, Harvard University [advisor: Andrew Strominger] (2017)
Thesis: **The Maximally Rotating Black Hole as a Critical Point in Astronomy**
A.M., Physics, Harvard University (2012)
A.B., Physics & Mathematics, Harvard College (2011)

GOVERNMENT FUNDING

National Science Foundation (**NSF**), Division of Physics (PHY)
CAREER award of \$414,762 (**grant number 2340457**) in Gravity Theory (2023–2028)
Currently supporting Vanderbilt University postdoctoral researcher **Roman Berens**

National Science Foundation (**NSF**), Division of Astronomical Sciences (AST)
Award of \$287,554 (**grant number 2307888**) in Stellar Astronomy & Astrophysics (2023–2026)
Currently supporting Vanderbilt University graduate student **Trevor Gravely**

PRIVATE FUNDING

Initial funding for development of BHEX from Fred Ehram
Raised \$350,000 in seed funding for BHEX at Vanderbilt University (2024)

Research funding from Will and Kacie Snellings
Raised \$300,000 in private funding to hire a postdoctoral researcher at Princeton University in 2021
Used to support **Alejandro Cárdenas-Avendaño** (about to start as faculty at Wake Forest University)

Research funding from the Jacob Goldfield Foundation
Raised \$300,000 in private funding to hire a postdoctoral researcher at Harvard University in 2018
Used to support **Shahar Hadar** (now faculty at the University of Haifa, Israel)

PRIZES & FELLOWSHIPS

Young Scientist Prize in General Relativity and Gravitation from the International Union of Pure and Applied Physics and **International Society on General Relativity and Gravitation**, 2024
New Horizons in Physics Prize from the **Breakthrough Prize Foundation**, 2024
Junior Fellowship from the **Harvard Society of Fellows**, 2017–2020
Joshua S. Friedman Graduate Student Dissertation Fellowship (Harvard University), 2015–2016
Donald and Cathleen Pfister Prize (Harvard College), 2011
Awarded to a graduating senior for excellent achievement in the natural sciences

TEACHING & ADVISING

Courses taught as faculty at Vanderbilt University:

- Physics 1020 (undergraduate): Physics For Future Leaders, Fall 2024
- Physics 8021 (graduate): Advanced Electrodynamics, Fall 2023
- Physics 8160 (graduate): General Theory of Relativity, Spring 2023 & Spring 2024
- Physics 3600 (undergraduate): Seminar in Presenting Physics Research, Fall 2022

Resident Tutor in Kirkland House (Harvard University), 2012-2018

Academic advisor for 5-7 sophomores every year

Star Family Prize Nominee for Excellence in Advising, 2013 & 2015

Derek Bok Center Certificate of Distinction in Teaching, Fall 2012 & Fall 2013

MENTORSHIP & SUPERVISION

Postdoctoral researchers

Roman Berens, Vanderbilt University (2023–)

Alejandro Cárdenas-Avendaño, Princeton University (2021–2023)

About to join the faculty at Wake Forest University

Shahar Hadar, Harvard University (2018–2020)

Now faculty at the University of Haifa, Israel

Graduate students

Trevor Gravely, Vanderbilt University (2022–)

Co-supervised at the University of California, Santa Barbara: **Joseph Farah** (2024–)

Co-supervised at Princeton University: **He Jia** (2023–), Hengrui Zhu (2021–2022)

Co-supervised at the Observatoire de Paris: Hadrien Pagnat (2021–2022, now at UCLA)

Co-supervised at Harvard University: **Delilah Gates** (2018–2021, now at Harvard BHI),

Mina Himwich (2019–2020, now at Princeton PCTS) and **Yichen Shi** (2017–2019)

Undergraduate students

Lennox Keeble, Princeton University (2024–)

SERVICE

Referee for:

Classical and Quantum Gravity (CQG), *Journal of Cosmology and Astroparticle Physics* (JCAP), *Journal of High Energy Physics* (JHEP), *Physics Letters B* (PLB), *Physical Review D* (PRD), *Physical Review Letters* (PRL), *Physical Review X* (PRX), *The Astrophysical Journal* (ApJ), *European Physical Journal C* (EPJC), *General Relativity and Gravitation* (GRG)

Organizer for the **Photon Ring Science Workshop** at Vanderbilt University, February 2024

SELECTED SOFTWARE

BlackHoleVision (led by T. Gravely): an **interactive iOS app** that simulates black hole lensing

Metric-Reconstruction (led by R. Berens): linearized metric perturbations of a Kerr black hole

AART (led by A. Cárdenas-Avendaño): an Adaptive Analytical Ray Tracing code for accretion disks

INVITED TALKS

University of Illinois Urbana-Champaign, *Astrophysics, Relativity, & Cosmology Seminar*, October 2024

Troy University, *Troy University Center for Relativity and Cosmology Seminar*, September 2024

Vanderbilt University, **Mathematics Department Colloquium**, August 2024

Joint Israeli Seminar Series on Gravitational Physics, July 2024

National Astronomical Observatory of Japan, *Black Hole Explorer Japan Workshop*, June 2024

Simons Collaboration on Extreme Electrodynamics of Compact Sources, *BH seminar*, March 2024

Southern Denmark University, *CP3-Origins Seminar*, March 2024

Johns Hopkins University, **Physics Department Colloquium**, January 2024

American Physical Society, Southeastern Section, *Invited Talk*, November 2023

NASA Goddard, *Infrared Science and Technology Integration Group Webinar*, November 2023

Astronomy on Tap, Nashville, October 2023
 University of California, Santa Cruz, *Astronomy Group Talk*, October 2023
 University of California, Santa Cruz, **Physics Department Colloquium**, October 2023
 Institut de Physique Théorique, CEA Saclay, *Conference on Black-Hole Microstructure V*, June 2023
 Harvard Black Hole Initiative, *Instrument Design Lab for Space VLBI*, May 2023
 Institute for Advanced Study, *IAS Astrophysics Coffee Talk*, May 2023
 CERN, *Theory Seminar*, March 2023
 Dartmouth College, **Physics Department Colloquium**, February 2023
 Carnegie Mellon University, **Physics Department Colloquium**, November 2022
 Stanford Institute for Theoretical Physics, *It from Qubit Seminar*, October 2022
 Stanford University, **Physics Department Colloquium**, October 2022
 Harvard Black Hole Initiative & CMSA, *Conference on Flat Holography*, June 2022
 McGill University, *High-Energy Theory Group Meeting*, May 2022
 Harvard Black Hole Initiative, *2022 Annual Conference*, May 2022
 Harvard University, *High-Energy Physics Seminar*, March 2022
 University of Amsterdam, *String Theory Seminar*, March 2022
 University of Cambridge, *DAMTP GR Seminar*, March 2022
 University of Mississippi, **Physics Department Colloquium**, November 2021
 Aveiro University, *Gravity and Gravitational Dynamics Seminar*, October 2021
 Albert Einstein Institute (MPI Potsdam), *Astrophysics and Relativity Seminar*, October 2021
 Harvard Black Hole Initiative, *Monday Foundations Seminar*, September 2021
 Harvard CMSA, *General Relativity Seminar*, September 2021
 Sixteenth Marcel Grossman Meeting, ‘Radio Astronomy in Space’ Session, July 2021
 University of Arizona, **Physics Department Colloquium**, April 2021
 Latin American Webinar on Physics, April 2021
 Vanderbilt University, *Gravity, Waves and Fluids Initiative Seminar*, April 2021
 Princeton University, *High-Energy Theory Seminar*, February 2021
 Next-Generation Event Horizon Telescope, *ngEHT Inaugural Science Meeting*, February 2021
 Harvard Black Hole Initiative, *2020 Annual Conference*, December 2020
 University of Bremen, *Space Science @ Drop Tower Seminar*, October 2020
 Harvard Black Hole Initiative, *Colloquium*, September 2020
 Princeton University, *Gravity Initiative Seminar*, September 2020
 University of California, Davis, *Fields, Strings, Gravity Seminar*, February 2020
 Harvard CMSA, *General Relativity Seminar*, February 2020
 Institute for Advanced Study, *IAS Astrophysics Seminar*, October 2019
 Brown University, *High-Energy Theory Seminar*, September 2018
 Harvard Black Hole Initiative, *2018 Annual Conference*, May 2018
 McGill University, *High-Energy Theory Seminar*, January 2018
 Harvard CMSA, *Mathematical Relativity Workshop*, May 2016
 Université Libre de Bruxelles, *Theoretical Physics Seminar*, May 2016
 Université Pierre et Marie Curie, Paris VI, *LPTHE Seminar*, January 2016
 McGill University, *High-Energy Theory Seminar*, November 2015
 Perimeter Institute, *Strong Gravity Seminar*, October 2015

TOP 3
 HIGHEST-IMPACT
 PUBLICATIONS

1) **Universal Interferometric Signatures of a Black Hole’s Photon Ring**

M. D. Johnson, A. Lupsasca (co-first authors) *et al.* [274 citations]
Science Advances **6**, no. 12, eaaz1310 (2020), [arXiv:1907.04329](#) [astro-ph.IM]

2) **Lensing by Kerr Black Holes**

S. E. Gralla and A. Lupsasca (alphabetized author list) [183 citations]
Physical Review D **101**, no. 4, 044031 (2020), [arXiv:1910.12873](#) [gr-qc]

3) **The Shape of the Black Hole Photon Ring: A Precise Test of Strong-Field Gravity**

S. E. Gralla, A. Lupsasca, and D. P. Marrone (alphabetized author list) [176 citations]
Physical Review D **102**, no. 12, 124004 (2020), [arXiv:2008.03879](#) [gr-qc]

PUBLICATIONS
(FIRST-AUTHOR
SYSTEM)

The Black Hole Explorer: using the photon ring to visualize black hole spacetime

P. Galison, M. D. Johnson, A. Lupsasca, T. Gravely, and R. Berens

Proceedings of SPIE **13902**, 130926R (2024), [arXiv:2406.11671 \[gr-qc\]](#)

The Black Hole Explorer: photon ring science, detection, and shape measurement

A. Lupsasca (first author) *et al.*

Proceedings of SPIE **13902**, 130926Q (2024), [arXiv:2406.09498 \[gr-qc\]](#)

The Black Hole Explorer: motivation and vision

M. D. Johnson *et al.*

Proceedings of SPIE **13902**, 130922D (2024), [arXiv:2406.12917 \[astro-ph.IM\]](#)

Photon Ring Interferometric Signatures Beyond The Universal Regime

H. Jia, E. Quataert, A. Lupsasca, and G. N. Wong

Physical Review D **110**, no. 8, 124052 (083044), [arXiv:2405.08804 \[astro-ph.HE\]](#)

Black Hole Polarimetry I: A Signature of Electromagnetic Energy Extraction

A. Chael, A. Lupsasca, G. N. Wong, and E. Quataert

The Astrophysical Journal **958**, no. 1, 65 (2023), [arXiv:2307.06372 \[astro-ph.HE\]](#)

Images and photon ring signatures of thick disks around black holes

F. H. Vincent, S. E. Gralla, A. Lupsasca, and M. Wielgus

Astronomy & Astrophysics **667**, A170 (2022), [arXiv:2206.12066 \[astro-ph.HE\]](#)

Photon ring test of the Kerr hypothesis

H. Pagnat, A. Lupsasca, F. H. Vincent, and M. Wielgus

Astronomy & Astrophysics **669**, A11 (2022), [arXiv:2206.02781 \[astro-ph.HE\]](#)

★ **Universal Interferometric Signatures of a Black Hole’s Photon Ring**

M. D. Johnson, A. Lupsasca (co-first authors) *et al.*

Science Advances **6**, no. 12, eaaz1310 (2020), [arXiv:1907.04329 \[astro-ph.IM\]](#)

PUBLICATIONS
(ALPHABETIZED
AUTHOR LIST)

Explanation for the absence of secondary peaks in black hole light curve autocorrelations

A. Cárdenas-Avendaño, C. Gammie, and A. Lupsasca

Physical Review Letters **133**, no. 13, 131402 (2024), [arXiv:2406.04176 \[astro-ph.HE\]](#)

Assessing the impact of instrument noise and astrophysical fluctuations on measurements of the first black hole photon ring

A. Cárdenas-Avendaño, L. Keeble, and A. Lupsasca

Physical Review D **109**, no. 12, 124052 (2024), [arXiv:2404.01083 \[gr-qc\]](#)

Gravitational Waves on Kerr Black Holes I:

Reconstruction of Linearized Metric Perturbations

R. Berens, T. Gravely, and A. Lupsasca

Classical and Quantum Gravity **41**, no. 19, 195004 (2024), [arXiv:2403.20311 \[gr-qc\]](#)

A Beginner’s Guide to Black Hole Imaging and Associated Tests of General Relativity

A. Lupsasca, D. R. Mayerson, B. Ripperda, and S. Staelens

Recent Progress on Gravity Tests (Chapter 6), Springer, Singapore (2024), [arXiv:2402.01290 \[gr-qc\]](#)

Black hole bulk-cone singularities

M. Dodelson, C. Iossa, R. Karlsson, A. Lupsasca, and A. Zhiboedov

Journal of High Energy Physics **2024**, 46 (2024), [arXiv:2310.15236 \[hep-th\]](#)

Prediction for the interferometric shape of the first black hole photon ring

A. Cárdenas-Avendaño and A. Lupsasca

Physical Review D **108**, no. 4, 064043 (2023), [arXiv:2305.12956](#) [gr-qc]

Adaptive Analytical Ray Tracing of Black Hole Photon Rings

A. Cárdenas-Avendaño, A. Lupsasca, and H. Zhu

Physical Review D **107**, no. 4, 043030 (2023), [arXiv:2211.07469](#) [gr-qc]

Photon Rings Around Warped Black Holes

D. Kapec, A. Lupsasca, and A. Strominger

Classical and Quantum Gravity **40**, no. 9, 095006 (2023), [arXiv:2211.01674](#) [gr-qc]

Holography of the Photon Ring

S. Hadar, D. Kapec, A. Lupsasca, and A. Strominger

Classical and Quantum Gravity **39**, no. 21, 215001 (2022), [arXiv:2205.05064](#) [gr-qc]

Observing the Inner Shadow of a Black Hole: A Direct View of the Event Horizon

A. Chael, M. D. Johnson, and A. Lupsasca

The Astrophysical Journal **918**, no. 1, 6 (2021), [arXiv:2106.00683](#) [astro-ph.HE]

Extreme Black Hole Anabasis

S. Hadar, A. Lupsasca, and A. Porfyriadis

Journal of High Energy Physics **2021**, 223 (2021), [arXiv:2012.06562](#) [hep-th]

Photon Emission from Circular Equatorial Kerr Orbiters

D. E. A. Gates, S. Hadar, and A. Lupsasca

Physical Review D **103**, no. 4, 044050 (2021), [arXiv:2010.07330](#) [gr-qc]

Photon Ring Autocorrelations

S. Hadar, M. D. Johnson, A. Lupsasca, and G. N. Wong

Physical Review D **103**, no. 10, 104038 (2021), [arXiv:2010.03683](#) [gr-qc]

Maximum Observable Blueshift from Circular Equatorial Kerr Orbiters

D. E. A. Gates, S. Hadar, and A. Lupsasca

Physical Review D **102**, no. 10, 104041 (2020), [arXiv:2009.03310](#) [gr-qc]

★ **The Shape of the Black Hole Photon Ring: A Precise Test of Strong-Field Gravity**

S. E. Gralla, A. Lupsasca, and D. P. Marrone

Physical Review D **102**, no. 12, 124004 (2020), [arXiv:2008.03879](#) [gr-qc]

On the Observable Shape of Black Hole Photon Rings

S. E. Gralla and A. Lupsasca

Physical Review D **102**, no. 12, 124003 (2020), [arXiv:2007.10336](#) [gr-qc]

Universal Polarimetric Signatures of the Black Hole Photon Ring

E. Himwich, M. D. Johnson, A. Lupsasca, and A. Strominger

Physical Review D **101**, no. 8, 084020 (2020), [arXiv:2001.08750](#) [gr-qc]

Null Geodesics of the Kerr Exterior

S. E. Gralla and A. Lupsasca

Physical Review D **101**, no. 4, 044032 (2020), [arXiv:1910.12881](#) [gr-qc]

★ **Lensing by Kerr Black Holes**

S. E. Gralla and A. Lupsasca

Physical Review D **101**, no. 4, 044031 (2020), [arXiv:1910.12873](#) [gr-qc]

Particle Motion Near High-Spin Black Holes

D. Kapec and A. Lupsasca

Classical and Quantum Gravity **37**, no. 1, 015006 (2019), [arXiv:1905.11406 \[hep-th\]](#)

Polarization Whorls from M87* at the Event Horizon Telescope

D. E. Gates, D. Kapec, A. Lupsasca, Y. Shi, and A. Strominger

Proceedings of the Royal Society A **476**, no. 2237, 20190618 (2020), [arXiv:1809.09092 \[hep-th\]](#)

Critical Emission from a High-Spin Black Hole

A. Lupsasca, A. P. Porfyriadis, and Y. Shi

Physical Review D **97**, no. 6, 064017 (2018), [arXiv:1712.10182 \[gr-qc\]](#)

Observational Signature of High Spin at the Event Horizon Telescope

S. E. Gralla, A. Lupsasca, and A. Strominger

MNRAS **475**, no. 3, 3829–3853 (2018), [arXiv:1710.11112 \[astro-ph.HE\]](#)

Inclined Pulsar Magnetospheres in General Relativity: Polar Caps for the Dipole, Quadrupole and Beyond

S. E. Gralla, A. Lupsasca, and A. Philippov

The Astrophysical Journal **851**, no. 2, 137 (2017), [arXiv:1704.05062 \[astro-ph.HE\]](#)

Force-Free Foliations

G. Compère, S. E. Gralla, and A. Lupsasca

Physical Review D **94**, no. 12, 124012 (2016), [arXiv:1606.06727 \[math-ph\]](#)

Pulsar Magnetospheres: Beyond the Flat Spacetime Dipole

S. E. Gralla, A. Lupsasca, and A. Philippov

The Astrophysical Journal **833**, no. 2, 258 (2016), [arXiv:1604.04625 \[astro-ph.HE\]](#)

Near-horizon Kerr Magnetosphere

S. E. Gralla, A. Lupsasca, and A. Strominger

Physical Review D **93**, no. 10, 104041 (2016), [arXiv:1602.01833 \[hep-th\]](#)

Electromagnetic Jets from Stars and Black Holes

S. E. Gralla, A. Lupsasca, and M. J. Rodriguez

Physical Review D **93**, no. 4, 044038 (2016), [arXiv:1504.02113 \[gr-qc\]](#)

Note on Bunching of Field Lines in Black Hole Magnetospheres

S. E. Gralla, A. Lupsasca, and M. J. Rodriguez

Physical Review D **92**, no. 4, 044053 (2015), [arXiv:1504.02112 \[gr-qc\]](#)

Exact Solutions for Extreme Black Hole Magnetospheres

A. Lupsasca and M. J. Rodriguez

Journal of High Energy Physics **2015**, 90 (2015), [arXiv:1412.4124 \[hep-th\]](#)

Force-Free Electrodynamics around Extreme Kerr Black Holes

A. Lupsasca, M. J. Rodriguez, and A. Strominger

Journal of High Energy Physics **2014**, 185 (2014), [arXiv:1406.4133 \[hep-th\]](#)

Quasinormal Quantization in de Sitter spacetime

D. L. Jafferis, A. Lupsasca, V. Lysov, G. S. Ng, and A. Strominger

Journal of High Energy Physics **2015**, 4 (2015), [arXiv:1305.5523 \[hep-th\]](#)