Leo C. Stein

Contact Information

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Education

Ph.D., Physics, Massachusetts Institute of Technology, Cambridge, MA, USA **May 2012**

Dissertation Advisor: Prof. Scott Hughes

Dissertation Title: *Probes of strong-field gravity*

B.S., Physics, California Institute of Technology, Pasadena, CA, USA **June 2006**

Degree conferred with honor.

Senior Thesis Advisors: Dr. Patrick Sutton and Prof. Alan Weinstein

Employment

Assistant Professor, University of Mississippi, Oxford, MS USA **August 2018–Present**

Senior Postdoctoral Researcher, Caltech, Pasadena, CA USA **September 2015–August 2018**

NASA Einstein Fellow, Cornell, Ithaca NY, USA **September 2012–August 2015**

Research and Teaching Assistant, MIT, Cambridge MA, USA **September 2006–May 2012**

Teaching Assistant, Caltech, Pasadena, CA, USA **Fall 2004, Spring 2005**

Summer Research Fellow, Caltech, Pasadena, CA, USA **June–September 2003/2005**

Research Interests

General relativity (GR), gravitation, and astrophysical phenomena which can elucidate gravity. One major theme is pushing numerical and analytical gravitational-wave (GW) predictions to the precision frontier in advance of next-generation observatories. A second major theme is using GWs to test GR against beyond-GR models, in both theory-independent and theory-dependent models. This involves numerical relativity and renormalization methods applied to specific effective field models for beyond-GR theories.

Honors and Awards

CAREER Award, NSF **2021–2026**

Einstein Postdoctoral Fellow, NASA **2012–2015**

Henry Kendall Teaching Award, Massachusetts Institute of Technology **2011**

Upperclass Merit Scholarship, California Institute of Technology **2005–2006**

Teaching Experience

Assistant Professor, University of Mississippi

Phys. 213, General physics I	**Spring 2021**
Phys. 401, Electromagnetism I	**Falls 2019–2021**
Phys. 402, Electromagnetism II	**Springs 2019–2021**
Phys. 463/4, Senior research project	**Fall 2020, Spring 2021**
Phys. 503/630, Graduate reading course	**Spring 2019, Falls 2020–2021**
Phys. 709, Advanced Mechanics I	**Fall 2018**
Phys. 750, General relativity II	**Spring 2020**

Guest Lecturer, California Institute of Technology

Ph236, General relativity **Fall 2017**

Ph237, Gravitational Waves **Spring 2016**

Guest Lecturer, Massachusetts Institute of Technology

8.901, Graduate Astrophysics I **Spring 2011**

Teaching Assistant, Massachusetts Institute of Technology

8.942, Cosmology **Fall 2011**

8.901, Graduate Astrophysics I **Spring 2011**

8.286, The Early Universe **Fall 2009**

Teaching Assistant, California Institute of Technology

Ph 7, Nuclear and Quantum Physics Lab **Spring 2005**

Ph 5, Analog Electronics for Physicists **Fall 2004**

Mentoring/ Supervision

Postdoctoral researchers

Károly Csukás **Fall 2021–present**

José Tomás Gálvez Ghersi **Fall 2019–present**

Graduate students

Lorena Magaña Zertuche, University of Mississippi **Fall 2018–present**

Sashwat Tanay, University of Mississippi **Fall 2018–present**

Maria (Masha) Okounkova, Caltech **Fall 2015–Summer 2019**

Baoyi Chen, Caltech **Fall 2016–Summer 2018**

Undergraduate students

Wayne Zhao, Harvard **Summer 2016**

Professional Activities, Outreach, and Service

LISA Consortium, Full member **2020–Present**

UMiss LISA Group leader **2020–Present**

Simulating eXtreme Spacetimes collaboration **2015–Present**

Executive committee member **2018–Present**

American Physical Society, member **2010–Present**

Division of Gravitational Physics

Executive Committee Member-at-Large **2016–2019**

Division of Astrophysics

Conference organizer

Workshop on Numerical Relativity beyond General Relativity, Benasque **June 2018**
Week-long international workshop, 59 participants

34$^{\text{th}}$ Pacific Coast Gravity Meeting (PCGM), Caltech **March 2018**
Two-day conference, $\sim$ 125 participants

Workshop on Unifying Tests of General Relativity, Caltech **July 2016**
Three day workshop, 52 participants

Seminar organizer

TAPIR seminar, Caltech	**Fall 2015–Spring 2018**
General Relativity Informal Tea-Time Series (GRITTS), MIT	**Fall 2011–Spring 2012**
MKI Journal Club, MIT	**Fall 2007–Spring 2010**

Conference session chair; Judge for best student speaker award

April APS meeting, Columbus, OH	**April 2018**
34$^{\text{th}}$ Pacific Coast Gravity Meeting (PCGM), Caltech	**March 2018**
33$^{\text{rd}}$ Pacific Coast Gravity Meeting (PCGM), UCSB	**March 2017**
"April" APS meeting, Washington D.C.	**January 2017**
32$^{\text{nd}}$ Pacific Coast Gravity Meeting (PCGM), CSU Fullerton	**April 2016**
Theoretical Astrophysics in Southern California (TASC), CSU Fullerton	**November 2015**

Journal referee

Classical and Quantum Gravity, Journal of Cosmology and Astroparticle Physics, General Relativity and Gravitation, Monthly Notices of the Royal Astronomical Society, Physics Letters B, Physical Review D, Physical Review Letters, Physical Review X, Reviews of Modern Physics, The Physics Teacher

Agency work

External reviewer for NSF, NASA

Outreach

Guest on the *Starts With a Bang* podcast
Episode 42: Black holes and gravitationa — **March 25, 2019**

Invited speaker for Latin American Webinar on Physics — **March 13, 2019**
Webinar 75: "Testing Einstein with numerical relativity"

Caltech astronomy public lecture series speaker — **March 2018**
Lecture: "The truth about black holes"

Astronomy on Tap public lecture series speaker and volunteer — **2016–2018**
Close to a monthly basis

Caltech astronomy public lecture series panelist and emcee — **2016–2018**
Approximately every three months

Invited guest lecture on black holes and gravitational waves — **November 2017**
Science of Space and Time, Hampshire College

Invited video Q&A session, public high school physics class — **June 2017**
The Nova Project school, Seattle

Guest on *The Titanium Physicists Podcast*
Episode 80: Picturing the Bach Hole — **August 21, 2019**
Episode 64: The edges of Einstein — **April 25, 2016**
Episode 62: Black Bells — **February 1, 2016**

Quora Q&A Session on gravitational waves and first detection — **February 17, 2016**
83.9k+ views, 20.8k+ followers

Invited guest host, public screening of *COSMOS* with Q&A, Science Cabaret/Cornell — **March/June 2014**

Invited public talk at *Frontiers of Cornell Astronomy*, Cornell Friends of Astronomy — **November 2013**

Invited video chat, *Topics in Physics* course, Stanford Education Program for Gifted Youth — **July 2013**

Computer Skills

Expert in Mathematica. Proficient in C/C++, Python, Bash, Javascript. Experience in Java, Haskell. Proficient at *nix and HPC. Markup languages: LaTeX, HTML, CSS, Markdown.

Software—Most contributions can be found at https://github.com/duetosymmetry. Member of the *Simulating eXtreme Spacetimes* (SXS) collaboration, contributor to the Spectral Einstein Code (SpEC). Member of the *Black Hole Perturbation Toolkit*. Author of `qnm` python package (https://github.com/duetosymmetry/qnm). Core collaborator on xAct (http://xact.es) abstract tensor calculus package for Mathematica. Coauthor of xTerior package for exterior differential geometry under xAct. Co-maintainer of community contributions at http://contrib.xact.es. Developed arXiv-keys browser extension/add-on for Chrome/Firefox. Author of `orcidlink` and coauthor of `gripapers` packages for LaTeX.

Submitted Publications

50. Magaña Zertuche, L., Mitman, K., Khera, N., **Stein, L. C.**, et al., (2021) *High Precision Ringdown Modeling: Multimode Fits and BMS Frames*, [arXiv:2110.15922].
49. Tanay, S., Cho, G., **Stein, L. C.**, (2021) *Action-angle variables of a binary black-hole with arbitrary eccentricity, spins, and masses at 1.5 post-Newtonian order*, [arXiv:2110.15351].
48. Clark, W. A., Gomes, M. W., Rodriguez-Gonzalez, A., **Stein, L. C.**, Strogatz, S. H., (2021) *Surprises in a classic boundary-layer problem*, [arXiv:2107.11624].
47. Okounkova, M, Farr, W. M., Isi, M., **Stein, L. C.**, (2021) *Constraining gravitational wave amplitude birefringence and Chern-Simons gravity with GWTC-2*, [arXiv:2101.11153].

Collaboration Publications

From 2008–2012, I was coauthor on 34 refereed LIGO and/or LIGO/Virgo collaboration publications. I only list short author-list publications below.

Refereed Publications

46. Gálvez Ghersi, J. T., **Stein, L. C.**, (2021) *Numerical renormalization group-based approach to secular perturbation theory*, Phys. Rev. E **104**, 034219 [arXiv:2106.08410].
45. Mitman, K., Khera, N., Iozzo, D. A. B., **Stein, L. C.**, et al., (2021) *Fixing the BMS frame of numerical relativity waveforms*, Phys. Rev. D **104**, 024051 [arXiv:2105.02300].
44. Iozzo, D. A. B., Khera, N., **Stein, L. C.**, et al., (2021) *Comparing Remnant Properties from Horizon Data and Asymptotic Data in Numerical Relativity*, Phys. Rev. D **103**, 124029 [arXiv:2104.07052].
43. Tahura, S., Nichols, D. A., Saffer, A., **Stein, L. C.**, Yagi, K. (2020) *Brans-Dicke theory in Bondi-Sachs form: Asymptotically flat solutions, asymptotic symmetries and gravitational-wave memory effects*, Phys. Rev. D **103**, 104026 [arXiv:2007.13799].
42. Tanay, S., **Stein, L. C.**, Gálvez Ghersi, J. T., (2020) *Integrability of eccentric, spinning black hole binaries up to second post-Newtonian order*, Phys. Rev. D **103**, 064066 [arXiv:2012.06586].
41. Gálvez Ghersi, J. T., **Stein, L. C.**, (2020) *A fixed point for black hole distributions*, Class. Quantum Grav. **38** 045012 [arXiv:2007.11578].
40. Okounkova, M., **Stein, L. C.**, Moxon, J., Scheel, M. A., Teukolsky, S. A., (2020) *Numerical relativity simulation of GW150914 beyond general relativity*, Phys. Rev. D **101**, 104016 [arXiv:1911.02588].
39. **Stein, L. C.**, Warburton, N., (2020) *Location of the last stable orbit in Kerr spacetime*, Phys. Rev. D **101**, 064007 [arXiv:1912.07609].

38. Okounkova, M., **Stein, L. C.**, Scheel, M. A., Teukolsky, S. A., (2019) *Numerical binary black hole collisions in dynamical Chern-Simons gravity*, Phys. Rev. D **100**, 104026 [arXiv:1906.08789].
37. Varma, V, *et al.* (2019) *Surrogate models for precessing binary black hole simulations with unequal masses*, Phys. Rev. Research **1**, 033015 [arXiv:1905.09300].
36. **Stein, L. C.**, (2019) `qnm`: *A Python package for calculating Kerr quasinormal modes, separation constants, and spherical-spheroidal mixing coefficients*, J. Open Source Softw., 4(42), 1683 [arXiv:1908.10377].
35. Boyle, M., *et al.* (**LCS** is corresponding author) (2019) *The SXS Collaboration catalog of binary black hole simulations*, Class. Quantum Grav. **36** 195006 [arXiv:1904.04831].
34. Barack, L., *et al.* (2019) *Black holes, gravitational waves and fundamental physics: a roadmap*, Class. Quantum Grav. **36** 143001 [arXiv:1806.05195].
33. Varma, V., **Stein, L. C.**, Gerosa, D., (2019) *The binary black hole explorer: on-the-fly visualizations of precessing binary black holes*, Class. Quantum Grav. **36** 095007 [arXiv:1811.06552], [project website].
32. Varma, V., Gerosa, D., **Stein, L. C.**, Hébert, F., Zhang, H., (2019) *High-accuracy mass, spin, and recoil predictions of generic black-hole merger remnants*, Phys. Rev. Lett. **122**, 011101 [arXiv:1809.09125].
31. Isi, M., **Stein, L. C.** (2018) *Measuring stochastic gravitational-wave energy beyond general relativity*, Phys. Rev. D **98**, 104025 [arXiv:1807.02123].
30. Prabhu, K., **Stein, L. C.** (2018) *Black hole scalar charge from a topological horizon integral in Einstein-dilaton-Gauss-Bonnet gravity*, Phys. Rev. D **98**, 021503(R) (Rapid Communication) [arXiv:1805.02668].
29. Gerosa, D., Hébert, F., **Stein, L. C.** (2018) *Black-hole kicks from numerical-relativity surrogate models*, Phys. Rev. D **97**, 104049 [arXiv:1802.04276].
28. Chen, B., **Stein, L. C.** (2018) *Deformation of extremal black holes from stringy interactions*, Phys. Rev. D **97**, 084012 [arXiv:1802.02159].
27. Chen, B., **Stein, L. C.** (2017) *Separating metric perturbations in near-horizon extremal Kerr*, Phys. Rev. D **96**, 064017 [arXiv:1707.05319].
26. Okounkova, M., **Stein, L. C.**, Scheel, M. A., Hemberger, D. A. (2017) *Numerical binary black hole mergers in dynamical Chern-Simons: I. Scalar field*, Phys. Rev. D **96**, 044020 [arXiv:1705.07924].
25. Tso, R., Isi, M., Chen, Y., **Stein, L. C.** (2017) *Modeling the Dispersion and Polarization Content of Gravitational Waves for Tests of General Relativity*, CPT and Lorentz Symmetry: pp. 205–208 [arXiv:1608.01284].
24. McNees, R., **Stein, L. C.**, Yunes, N. (2016) *Extremal Black Holes in Dynamical Chern-Simons Gravity*, Class. Quantum Grav. **33** 235013 [arXiv:1512.05453].
23. Flanagan, É. É., Nichols, D. A., **Stein, L. C.**, Vines, J. (2016) *Prescriptions for Measuring and Transporting Local Angular Momenta in General Relativity*, Phys. Rev. D **93**, 104007 [arXiv:1602.01847].
22. Yagi, K., **Stein, L. C.** (2016) *Black Hole Based Tests of General Relativity*, Class. Quantum Grav. **33** 054001 [arXiv:1602.02413].
21. Yagi, K., **Stein, L. C.**, Yunes, N. (2016) *Challenging the Presence of Scalar Charge and Dipolar Radiation in Binary Pulsars*, Phys. Rev. D **93** 024010 [arXiv:1510.02152].
20. Berti, E., (5 authors), **Stein, L. C.**, (46 more authors) (2015) *Testing General Relativity with Present and Future Astrophysical Observations*, Class. Quantum Grav. **32** 243001 [arXiv:1501.07274].
19. Tsang, D., Galley, C. R., **Stein, L. C.**, Turner, A. (2015) *"Slimplectic" Integrators: Variational Integrators for General Nonconservative Systems*, ApJ **809** L9 [arXiv:1506.08443].

18. Yagi, K., **Stein, L. C.**, Pappas, G., Yunes, N., Apostolatos, T. (2014) *Why I-Love-Q: Explaining why universality emerges in compact objects*, Phys. Rev. D **90** 063010 [arXiv:1406.7587].
17. **Stein, L. C.** (2014) *Rapidly rotating black holes in dynamical Chern-Simons gravity: Decoupling limit solutions and breakdown*, Phys. Rev. D **90** 044061 [arXiv:1407.2350].
16. **Stein, L. C.**, Yagi, K., Yunes, N. (2014) *Three-Hair Newtonian Relations for Rotating Stars*, ApJ **788** 15 [arXiv:1312.4532].
15. **Stein, L. C.**, Yagi, K. (2014) *Parameterizing and constraining scalar corrections to general relativity*, Phys. Rev. D **89** 044026 [arXiv:1310.6743].
14. Yagi, K., **Stein, L. C.**, Yunes, N., Tanaka, T. (2013) *Isolated and Binary Neutron Stars in Dynamical Chern-Simons Gravity*, Phys. Rev. D **87** 084058 [arXiv:1302.1918].
13. Yagi, K., **Stein, L. C.**, Yunes, N., Tanaka, T. (2012), *Post-Newtonian, Quasi-Circular Binary Inspirals in Quadratic Modified Gravity*, Phys. Rev. D **85** 064022 [arXiv:1110.5950].
12. Vigeland, S., Yunes, N., **Stein, L. C.** (2011), *Bumpy black holes in alternative theories of gravity*, Phys. Rev. D **83** 104027 [arXiv:1102.3706].
11. Yunes, N., **Stein, L. C.** (2011), *Nonspinning black holes in alternative theories of gravity*, Phys. Rev. D **83** 104002 [arXiv:1101.2921].
10. **Stein, L. C.**, Yunes, N. (2011), *Effective gravitational wave stress-energy tensor in alternative theories of gravity*, Phys. Rev. D **83** 064038 [arXiv:1012.3144].
9. Lutomirski, A., Tegmark, M., Sanchez, N. J., **Stein, L. C.**, Urry, W. L., Zaldarriaga, M. (2011), *Solving the corner-turning problem for large interferometers*, MNRAS **410** 2075 [arXiv:0910.1351].
8. Sutton, P., Jones, G., Chatterji, S., Kalmus, P., Leonor, I., Poprocki, S., Rollins, J., Searle, A., **Stein, L.**, Tinto, M., Was, M. (2010), *X-Pipeline: an analysis package for autonomous gravitational-wave burst searches*, New J. Phys. **12** 053034 [arXiv:0908.3665].
7. Chatterji, S., Lazzarini, A., **Stein, L.**, Sutton, P., Searle, A. (2006), *Coherent network analysis technique for discriminating gravitational-wave bursts from instrumental noise*, Phys. Rev. D **74** 082005 [arXiv:gr-qc/0605002].

Unrefereed Publications

6. Galley, C. R., Tsang, D., **Stein, L. C.** (2014) *The principle of stationary nonconservative action for classical mechanics and field theories*, [arXiv:1412.3082].
5. **Stein, L. C.** (2014), *Note on Legendre decomposition of the Pontryagin density in Kerr*, [arXiv:1407.0744].
4. **Stein, L. C.** (2012), *Probes of Strong-field Gravity*, Ph.D. thesis at Massachusetts Institute of Technology [hdl:1721.1/77256].
3. Betancourt, M., **Stein, L. C.** (2011) *The Geometry of Hamiltonian Monte Carlo*, [arXiv:1112.4118].
2. **Stein, L. C.** (2009), *Binary Inspiral Gravitational Waves from a Post-Newtonian Expansion*, Contribution to the Wolfram Demonstrations Project, `http://demonstrations.wolfram.com/BinaryInspiralGravitationalWavesFromAPostNewtonianExpansion/`
1. **Stein, L. C.** (2006), *Gravitational Wave Burst Source Localization in a Coherent Network Analysis*, Senior thesis at California Institute of Technology

Invited Talks

40.	DAMTP (University of Cambridge), HEP/GR colloquium,	January 2022
39.	SISSA, Current challenges in gravitational physics workshop,	April 2021
38.	Flatiron CCA, Gravitational wave astronomy group seminar,	January 2021
37.	University of Birmingham, astrophysics seminar	September 2020
36.	Albert Einstein Institute, ACR division seminar	July 2020
35.	Black Hole Perturbation Toolkit, Spring 2020 workshop	May 2020

34. American Physical Society Meeting April 2020
33. UVA, physics department colloquium November 2019
32. UT Dallas, physics department colloquium October 2019
31. Northwestern University, CIERA astrophysics seminar May 2019
30. ETH-ITS Zurich, "New horizons for gravity" workshop May 2018
29. UC San Diego, astrophysics seminar March 2018
28. UC Berkeley, 4D particle physics seminar March 2018
27. Kyoto University, YKIS2018a Symposium February 2018
26. Oakland University physics seminar February 2018
25. University of Wisconsin-Milwaukee gravity seminar January 2018
24. Caltech/JPL Gravitational-Wave (CaJAGWR) seminar January 2018
23. ICN UNAM, Relativity seminar December 2017
22. University of Mississippi, Astrophysics seminar November 2017
21. University of Florida, Astrophysics seminar November 2017
20. University of Nottingham, Mathematical Physics seminar July 2017
19. Sapienza University of Rome, New Frontiers in Gravitational-Wave Astrophysics June 2017
18. Rochester Institute of Technology, CCRG seminar March 2017
17. Penn State, IGC seminar March 2017
16. University of Mississippi, Strong Gravity/Binary Dynamics workshop February/March 2017
15. SUNY Stony Brook, "The universe through gravitational waves" December 2016
14. University of Pennsylvania, New Frontiers in Gravitational Radiation workshop December 2016
13. Cambridge MA, Event Horizon Telescope collaboration meeting November/December 2016
12. Northwestern University CIERA, "Fellows at the Frontiers" August/September 2016
11. Princeton University, GR@100++ panel discussion April 2016
10. Cambridge MA, Einstein fellows symposium October 2014
9. Perimeter Institute, Strong gravity seminar October 2014
8. Cornell University, Friends of astronomy outreach event November 2013
7. Cambridge MA, Einstein fellows symposium October 2013
6. SUNY Geneseo, Physics colloquium October 2013
5. University of Maryland, UMD gravity seminar October 2013
4. Yale University, YCAA seminar September 2013
3. Kyoto University, YITP long-term workshop June 2013
2. Cambridge MA, Einstein fellows symposium October 2012
1. Cornell University, Relativity lunch November 2011

Contributed Talks (selected)

20.	American Physical Society Meeting	April 2021
19.	American Physical Society Meeting	April 2019
18.	American Physical Society Meeting	April 2018
17.	Pacific Coast Gravity Meeting	March 2017
16.	American Physical Society Meeting	~~April~~ January 2017
15.	Testing Gravity 2017	January 2017
14.	21^{st} International meeting on GR (GR21)	July 2016
13.	American Physical Society Meeting	April 2016
12.	Eastern Gravity Meeting	May 2015
11.	American Physical Society Meeting	April 2015
10.	NEB 16 Recent developments in gravity	September 2014
9.	American Physical Society Meeting	April 2014
8.	XXVII Texas symposium on relativistic astrophysics	December 2013
7.	20^{th} International meeting on GR (GR20)	July 2013
6.	Eastern Gravity Meeting	June 2013
5.	American Physical Society Meeting	April 2013
4.	Caltech TAPIR Seminar	December 2011
3.	Eastern Gravity Meeting	June 2011
2.	American Physical Society Meeting	April 2011
1.	American Physical Society Meeting	April 2010

References

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