

Jeffrey S. Hazboun

NANOGrav Physics Frontiers Center Postdoctoral Fellow

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Curriculum Vitae

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ACADEMIC POSITIONS

- **NANOGrav Physics Frontiers Center Postdoctoral Fellow**
University of Washington Bothell, August 2018 - Present
- **NANOGrav Physics Frontiers Center Postdoctoral Fellow**
University of Texas Rio Grande Valley, August 2016 - July 2018
- **Visiting Assistant Professor**
Hendrix College, August 2015-July 2016
- **Postdoctoral Teaching Position/ Head Online Class Developer,**
Utah State University, Logan UT September 2014 - August 2015
- **Visiting Scholar,** Center for Relativistic Astrophysics, Georgia Tech
Atlanta, Georgia, June 2012 - May 2013

EDUCATION

- **PhD Physics** December 2014
"Conformal gravity and time"
Advisor: James T. Wheeler
Utah State University, Logan, Utah
- **MS Physics (Mathematics Minor)** June 2008
"The effects of negative-energy shells on Schwarzschild spacetime"
Advisor: Tevian Dray
Oregon State University, Corvallis, Oregon
Physics PhD Student, September 2008 - June 2009
- **Post Baccalaureate Work in Physics** September 2005-June 2006
Oregon State University, Corvallis, Oregon
- **BS Biology** December 1999
State University of New York, College of Environmental Science and Forestry, Syracuse, New York

RESEARCH INTERESTS

Gravitational wave astronomy with pulsar timing arrays, pulsars and the interstellar medium, general relativity, conformal symmetry, multi-messenger astronomy, cosmology, Cartan geometry, quantum gravity

PAPERS

- **The NANOGrav 11-Year Data Set: Evolution of Gravitational Wave Background Statistics**
J.S.Hazboun, [and 63 others]
Submitted to Astro. Phys. Jour., arXiv: 1909.08644
- **Realistic sensitivity curves for pulsar timing arrays**
J.S.Hazboun, J.D. Romano, T.L. Smith
Submitted to Physical Review D, arXiv: 1907.04341

- **The Astrophysics of Nanohertz Gravitational Waves**
S. Burke-Spolaor, S.R.Taylor, M.Charisi, T.Dolch, J.S.Hazboun, [and 10 others]
Astron. Astrophys. Rev. 27 (2019) no.1, 5 , *arXiv:1811.08826*
- **A Second interstellar medium event from the timing of PSR J1713+0746**
M. T. Lam, J. A. Ellis, G. Grillo, M. L. Jones, J.S. Hazboun, [and 32 others]
Astrophys.J. 861 (2018) no.2, 132 ,*arXiv:1712.03651v1*
- **An Acoustical Analogue of a Galactic-scale Gravitational-Wave Detector**
Michael T. Lam, Joseph D. Romano, Joey S. Key, Marc Normandin, Jeffrey S. Hazboun
American Journal of Physics 86, 755 (2018), *arXiv:1803.05285 [physics.ed-ph]*
- **Constructing an Explicit AdS/CFT Correspondence with Cartan Geometry**
Jeffrey S. Hazboun
Nucl. Phys B 929, (2018) DOI: 10.1016/j.nuclphysb.2018.02.006
- **Power radiated by a binary system in a de Sitter Universe**
Béatrice P. Bonga and Jeffrey S. Hazboun
*Phys.Rev. D*96 (2017) no.6, 064018 DOI: 10.1103/PhysRevD.96.064018
- **Time and dark matter from the conformal symmetries of Euclidean space**
Jeffrey S. Hazboun and James T. Wheeler
Classical & Quantum Gravity Volume 31 (2014) 215001 DOI: 10.1088/0264-9381/31/21/215001
- **The Effect of Negative-Energy Shells on the Schwarzschild Black Hole**
Jeffrey S. Hazboun and Tevian Dray
General Relativity and Gravitation Volume 42 (2010) 1457-1467, DOI: 10.1007/s10714-009-0916-5

Selected Collaboration Papers

- **The International Pulsar Timing Array: Second data release**
B.B.P. Perera, [and 74 others, including Jeffrey S. Hazboun]
Submitted to MNRAS, arXiv 1909.04534
- **The NANOGrav 11-Year Data Set: Limits on Gravitational Waves from Individual Black Hole Binaries**
K. Aggarwal, [and 62 others, including Jeffrey S. Hazboun]
Astrophys.J. 880 (2019) no.2, 116 , *arXiv 1812.11585*
- **The NANOGrav 11-Year Data Set: Constraints on the Stochastic Gravitational Wave Background**
Z. Arzoumanian, [and 59 others, including Jeffrey S. Hazboun]
Astrophys.J. 859 (2018) no.1, 47 , *arXiv 1801.02617v1*

Proceedings

- **C7 multi-messenger astronomy of GW sources**
Jeffrey S. Hazboun and Shane L. Larson
General Relativity and Gravitation Volume 46 (2014) 1771,
DOI: 10.1007/s10714-014-1771-6
- **A systematic construction of curved phase space:
A gravitational gauge theory with symplectic form**
Jeffrey S. Hazboun and James T. Wheeler
Journal of Physics Conference Series 360 (2012) 012013, DOI: 10.1088/1742-6596/360/1/012013

Selected White Papers and Technical Papers

- **Physics Beyond the Standard Model With Pulsar Timing Arrays**
X. Siemens, Jeffrey S. Hazboun, [and 8 others]
arXiv:1907.04960
- **The NANOGrav Program for Gravitational Waves and Fundamental Physics**
A. Brazier, [and 13 others, including Jeffrey S. Hazboun]
arXiv:1908.05356
- **NANOGrav Education and Outreach: Growing a Diverse and Inclusive Collaboration for Low-Frequency Gravitational Wave Astronomy**
P.T.Baker, [and 26 others, including Jeffrey S. Hazboun]
arXiv:1907.07348
- **Null-stream pointing with pulsar timing arrays**
Jeffrey S. Hazboun and Shane L. Larson
arXiv:1607.03459
- **Limiting alternative theories of gravity using gravitational wave observations**
Jeffrey S. Hazboun, Manuel Pichardo Marcano and Shane L. Larson
arXiv:1311.3153

PROFESSIONAL SOCIETIES AND COLLABORATIONS

- North American Nanohertz Observatory for Gravitational Waves Collaboration
- International Pulsar Timing Array Collaboration
- International Gravitational Outreach Group
- LISA Consortium
- American Physical Society
- American Astronomical Society

TEACHING EXPERIENCE

- **Teaching Positions**
 - **Visiting Assistant Professor**, Hendrix College, Conway, Arkansas, Fall 2015 - Spring 2016
Astronomy, Cosmology, Quantum Mechanics and General Physics I
Mentored 4 undergraduate researchers.
 - **Physics Instructor**, Utah State University, Logan, Utah, Spring 2015
General Physics II: Instructor of Record for a 165 person Physics for the Life Sciences class. Supervised nine teaching assistants.
 - **Astronomy Instructor**, Utah State University, Logan, Utah, Fall 2014
Instructor of record for a 300+ person astronomy class. Supervised two teaching assistants.
 - **Research Advisor**, Utah State University, Logan, Utah, Fall 2013-Spring 2014
Mentored a senior research project on multi-messenger astronomy using gravitational waves.
 - **Online Physics Course Developer & Instructor**, Utah State University, Logan, Utah, 2012-2014
The Universe: Proposed, developed and taught an online cosmology class for non-science students. Continuously offered for the last 7 semesters. Over 400 students have taken this class.
 - **Physics Instructor**, Utah State University, Logan, Utah, Summer 2011
General Physics I: Instructor of Record
 - **Teaching Assistant**, Utah State University, Logan, Utah, Fall 2009-Spring 2012
General Physics I: Recitation Leader and Lab Instructor
General Physics II: Recitation Leader and Lab Instructor

- **Teaching Assistant**, Oregon State University, Corvallis, Oregon Fall 2006-Spring 2009
Paradigms in Physics TA: NSF funded higher division class reform project.
Facilitated group work and took part in curriculum meetings.
Physics for the Life Sciences: Recitation Leader and Lab Instructor
General Physics II: Lab Instructor
- **MCAT Physics Instructor** Princeton Review, Portland, Oregon, Summer 2007
Developed curriculum to help students review for physics portion of the MCAT exam.
Taught students test-taking strategies to prepare for a stressful and fast-paced exam.
- **Courses Instructed**, *Textbook* (Students \times Credit Hours) [cumulative]
 - Quantum Mechanics, *Griffiths* (39 hrs)
 - Cosmology, *Ryden* (27 hrs)
 - Astronomy, *Bennett, et al.* (1300 hrs)
 - The Universe, *Ratcliffe* (1200 hrs)
 - Physics for the Life Sciences 1, *Cutnell & Johnson* (75 hrs)
 - Physics for the Life Sciences 2, *Cutnell & Johnson* (450 hrs)
 - Physics for Engineers 1, *Halliday & Resnick* (75 hrs)

ACADEMIC SERVICE

- Data Challenge Working Group Co-Chair, International Pulsar Timing Array
- Diversity and Equity Group Co-Chair, International Gravitational Outreach Group
- Local Organizing Committee, Conferences for Undergraduate Women in Physics at Seattle
- Local Organizing Committee Chair, NANOGrav Spring Meeting 2019
- LISA Data Analysis Workshop, AAS233 2019
- Science Organizing Committee, LISA Symposium 2018
- Science Organizing Committee, NANOGrav Spring Meeting 2018
- Science Organizing Committee, NANOGrav Spring Student Workshop 2018
- Student Workshop Organizer, IPTA Meeting 2017
- Referee for Monthly Notices of the Royal Astronomical Society
- Referee for Classical and Quantum Gravity
- Referee for General Relativity and Gravitation
- Referee for Physical Review
- Referee for European Journal of Physics

SOFTWARE DEVELOPMENT

Lead Developer

- **hasasia** Python package for calculating pulsar timing array sensitivity curves and signal-to-noise ratios.
<https://pypi.org/project/hasasia/>
- **Pulsar Data Toolbox** Python package for accessing pulsar data files.
<https://pypi.org/project/pdat/>
- **Pulsar Signal Simulator** Python package for simulating pulsar observation data.
<https://github.com/PsrSigSim/PsrSigSim>
- **La Forge** Python package for making plots from Bayesian analyses of PTA data.
<https://pypi.org/project/la-forge/>

Development Team

- **enterprise** Python package for bayesian PTA data analysis.
<https://github.com/nanograv/enterprise>
- **enterprise_extensions** Python package for building bayesian analysis models.
https://github.com/stevertaylor/enterprise_extensions
- **Tabletop PTA** Python package for an acoustical PTA demonstration.
https://pypi.org/project/tabletop_pta/

ADVANCED GRADUATE SCHOOLS

- **53rd Cracow School of Theoretical Physics** Zakopane, Poland. June 2013
Eight day school. Topics: conformal symmetry, AdS/CFT, and quantum gravity.
- **Higher Gauge Theory, Topological Quantum Field Theory and Quantum Gravity School and Workshop** Lisbon, Portugal, February 2011
Seven day school. Topics: topology, category theory and quantum gravity.
- **PASI Quantum Gravity Summer School** Morelia, Mexico, June 2010
Ten day school. Topics: various approaches to quantum gravity lectured.

INVITED TALKS

- **Professional**
 - **Northwest APS Meeting** PTA Overview, May, 2019
*The Search for Lumbering Giants:
Observing the Nanohertz Gravitational-Wave Sky with Pulsar Timing Arrays*
 - **Gravitational Wave Physics and Astronomy Workshop** PTA Overview, December, 2019
Current Status of Pulsar Timing Array Gravitational Wave Astronomy
 - **University of Washington Bothell** PSD Seminar, December, 2018
Observing the Nanohertz Gravitational-Wave Sky with Pulsar Timing Arrays
 - **University of Washington Seattle** AstroLunch Talk, February, 2018
A Galactic Scale Gravitational Wave Detector: The NANOGrav 11yr Limits
 - **University of Washington Bothell** PSD Seminar, November, 2017
*The NANOGrav Pulsar Timing Array:
Using simulations to characterize our galactic gravitational wave detector.*
 - **University of Texas Rio Grande Valley** ARCC Meeting, February, 2017
Simulating Pulsar Signals for Noise Characterization of PTAs
 - **University of Arkansas** Colloquium, February, 2016
Gravitational Wave Astronomy in the 2nd Century of GR
 - **Western Washington University** Colloquium, May, 2015
A New Window into the Cosmos
 - **Brigham Young University** Theory Seminar, February, 2015
Gravitational Gauge Theory and the Dark Cosmological Constituents
 - **Center for Relativistic Astrophysics** Departmental Colloquium, March, 2013
Biconformal Space & Testing Alternative Theories of Gravity using Multi-Messenger Astronomy
 - **Utah State University** Colloquium, February, 2013
Best Practices for the Online Classroom
 - **Utah State University** Colloquium, September 2010
Curved Phase Space from conformal symmetry
 - **Oregon State Physics Colloquium** Corvallis, Oregon, March 2009
Spherical Shells in a Schwarzschild Background
- **Public**
 - **Science Wednesday Panel Discussion** King's Live Music, Conway, Arkansas, February 2015
The Science of Time Travel

- **Science Fiction Club Talk** Hendrix College, Conway, Arkansas, October 2015
Black Holes and Wormholes
- **Science Unwrapped** Utah State University, Logan, Utah, February 2013
Explore to Conserve (500 person public lecture)
- **Conservation Club Talk** Weber State Conservation Club, Ogden, Utah, February 2012
A Scientist's Role in Conservation
- **Science Unwrapped** Swaner Ecocenter, Park City, Utah, February 2011
A Scientist's Role in Modern Exploration
- **Science Interview for National Geographic**, November 2009
Interviewed for *Phenomena: A science salon hosted by National Geographic* about the physics in the movie "Men Who Stare at Goats".
- **Cache Valley Stargazers Talk** Logan, Utah, November 2009
Black Holes: Ninjas of the Night Sky

RESEARCH TALKS PRESENTED

1. **GR22/Amaldi13** Valencia, Spain, July, 2019
"Realistic Pulsar Timing Array Sensitivity Curves"
Jeffrey S. Hazboun, Joseph D. Romano, Tristan L. Smith
2. **American Physical Society April Meeting** Denver, Colorado, April, 2019
"Realistic Pulsar Timing Array Sensitivity Curves"
Jeffrey S. Hazboun, Joseph D. Romano, Tristan L. Smith
3. **American Astronomical Society Meeting** Seattle, Washington, January, 2019
"Bayesian Monitoring of Solar Electron Density Using NANOGrav Data sets"
Jeffrey S. Hazboun
4. **AstroNWxSW** Vancouver, British Columbia, November, 2018
"Bayesian Monitoring of the Solar Wind with Pulsar Timing Arrays"
Jeffrey S. Hazboun
5. **LISA Symposium** Chicago, Illinois, July, 2018
"The International Pulsar Timing Array Mock Data Challenge"
Jeffrey S. Hazboun on behalf of the IPTA Data Challenge Working Group
6. **IPTA 2018** Albuquerque, New Mexico, June, 2018
"Evolution of the Detection Statistics in the NANOGrav Dataset"
Jeffrey S. Hazboun
7. **Northwest Section APS Meeting** Tacoma, Washington, June, 2018
"Noise Evolution in the NANOGrav 11 Year Data Set"
Jeffrey S. Hazboun
8. **Python in Astronomy** New York, New York, May, 2018
"Publishing a Gravitational Wave Stochastic Background Analysis"
Jeffrey S. Hazboun
9. **American Physical Society April Meeting** Columbus, Ohio, April, 2018
"Slicing the NANOGrav 11 Year Data Set"
Jeffrey S. Hazboun
10. **Spring NANOGrav Meeting** Charlottesville, Virginia, March, 2018
"Evolution of the NANOGrav 11 Year Data Set"
Jeffrey S. Hazboun
11. **Fall NANOGrav Meeting** Easton, Pennsylvania, October, 2017
"Slicing the NANOGrav 11 Year Data Set"
Jeffrey S. Hazboun

12. **International Pulsar Timing Array** Sèvres, France, July, 2017
"The NANOGrav pulsar signal simulator"
 Jeffrey S. Hazboun
13. **American Physical Society April Meeting** Washington, DC, January, 2017
"Late-time quadrupolar gravitational wave power in de Sitter space"
 Jeffrey S. Hazboun and Béatrice Bonga
14. **American Astronomical Society 227th Meeting** Grapevine, Texas, January, 2017
"Null Stream Approach with PTAs: Noise Characterization and Excess Power"
 Jeffrey S. Hazboun
15. **Fall NANOGrav Meeting** Urbana, Illinois, October, 2016
"Assessing the null stream approach for source localization in PTAs"
 Jeffrey S. Hazboun
16. **Int. Soc. for General Relativity and Gravitation 21st Meeting** New York City, New York, July, 2016
"Comparing transverse-traceless decompositions of symmetric tensors"
 Jeffrey S. Hazboun and Béatrice Bonga
17. **American Physical Society April Meeting** Salt Lake City, Utah, April, 2016
"Null Stream Approach for finding Sky Position of Pulsar Timing Array sources"
 Jeffrey S. Hazboun and Shane L. Larson
18. **Midwest Gravity Meeting** Evanston, Illinois, October, 2015
"A Cartan Geometry approach to the AdS/CFT "
 Jeffrey S. Hazboun
19. **American Physical Society April Meeting** Baltimore, Maryland, April 2015
"Tracing the AdS/CFT Degrees of Freedom using Cartan Geometry"
 Jeffrey S. Hazboun
20. **American Astronomical Society 225th Meeting** Seattle, Washington, January 2015
"Pulsar Timing Array Source Location Using the Null Signal Approach" (Poster)
 Jeffrey S. Hazboun and Shane L. Larson
21. **Midwest Gravity Meeting** Rochester, MI, November, 2014
"Conformal gravity, dark matter and time"
 Jeffrey S. Hazboun and James T. Wheeler
22. **APS Four Corners Meeting** Orem, Utah, October 2014
"Conformal gravity, dark matter and time"
 Jeffrey S. Hazboun and James T. Wheeler
23. **Midwest Gravity Meeting** Milwaukee, Wisconsin, October 2013
"Time from the conformal symmetries of a Euclidean space"
 Jeffrey S. Hazboun and James T. Wheeler
24. **Loops 13: International Conference on Quantum Gravity** Waterloo, Canada, July 2013
"Lorentzian geometry from the conformal symmetries of a Euclidean space"
 Jeffrey S. Hazboun and James T. Wheeler
25. **GR20/AMALDI 10** Warsaw, Poland, July 2013
"Testing Bimetric and Massive Gravity Theories using Multi-Messenger Astronomy"
 Jeffrey S. Hazboun and Shane L. Larson
26. **53rd Cracow School of Theoretical Physics** Zakopane, Poland, June 2013
"Lorentzian spin connection from the conformal symmetries of a Euclidean space"
 Jeffrey S. Hazboun and James T. Wheeler
27. **Pacific Coast Gravity Meeting** Davis, California, March 2013
"General relativity in signature changing phase space"
 Jeffrey S. Hazboun and James T. Wheeler

28. **Pacific Coast Gravity Meeting** Santa Barbara, California, March 2012
"General relativity in phase space with a natural notion of time"
 Jeffrey S. Hazboun and James T. Wheeler
29. **Loops 11: International Conference on Quantum Gravity** Madrid, Spain, May 2011
"A systematic construction of curved phase space: A gravitational gauge theory with symplectic form"
 Jeffrey S. Hazboun and James T. Wheeler
30. **Intermountain Graduate Research Symposium** Logan, Utah, March 2010
"Quantum gravity in relativistic phase space"
 Jeffrey S. Hazboun and James T. Wheeler
31. **12th Marcel Grossman Gravity Meeting** Paris, France, July 2009
"Multiple Spherical Shells in Schwarzschild Spacetime" (MS Work)
 Jeffrey S. Hazboun and Tevian Dray
32. **TEXAS Symposium on Relativistic Astrophysics** Vancouver, Canada, December 2008
"Multiple Spherical Shells in Schwarzschild Spacetime" (Poster, MS Work)
 Jeffrey S. Hazboun and Tevian Dray
33. **Pacific Coast Gravity Meeting** Eugene, Oregon, March 2009
"Single Spherical Shells in Schwarzschild Spacetime" (MS Work)
 Jeffrey S. Hazboun and Tevian Dray

STUDENT RESEARCH PROJECTS ---

- **Min Young Kim** University of Washington Seattle, 2018-Present
Bayesian Pulsar Timing trials
- **Kyle Gersbach** University of Washington Bothell, 2018-Present
Speed and workflow in the Pulsar Signal Simulator
- **Jacob Hesse** University of Washington Bothell, 2017-2018
Efficiently Simulating NANOGrav Pulsars
- **Amelia Henkel** REU UT Rio Grande Valley, Brownsville, Texas, Summer 2017
Dispersing Simulated Baseband Pulsar Signals
- **Cassidy Wagner** REU UT Rio Grande Valley, Brownsville, Texas, Summer 2017
Simulating Interstellar Medium Effects with Convolution
- **Chris Griffin** Hendrix College, Conway, Arkansas, 2015-2016
Conformal Diagrams of Crossing Spherical Shells in Schwarzschild Spacetime
- **Devon Roell** Hendrix College, Conway, Arkansas, 2015-2016
The Quantum Exchange Force and Gravity
- **Eric Mullins**, Hendrix College, Conway, Arkansas, 2015-2016
Localizing Gravitational Wave Sources with Noisy Null Signals
- **Connor Nelson**, Hendrix College, Conway, Arkansas, 2015-2016
Localizing Multiple Gravitational Wave Sources with Null Signals
- **Manuel Pichardo Marcano** Utah State University, Logan, Utah, 2012-2013
Multi-messenger Pulsar Timing Array Sources and Propagation Tests

GRANTS, HONORS and AWARDS ---

1. **Amazon Web Services, Research Grant 50,000 Credits**, 2019
2. **USU College of Science Graduate Teacher of the Year**, 2013
3. **Graduate Student Senate: Graduate Enhancement Award, \$4000**, 2013
4. **Travel Grant and Support, Loops '13, \$1000**, 2013

5. Travel Grant and Support, 53rd Cracow School of Theoretical Physics, \$3000, 2013
6. Gene Adams Endowed Scholarship, \$400, Spring 2011
7. Travel Grant and Support, Higher Gauge Theory, Topological Quantum Field Theory and Quantum Gravity School and Workshop, \$1000, 2013
8. Travel Grant and Support, PASI Quantum Gravity Summer School, \$2000, 2013
9. National Geographic Explorer's Grant, Kamchatka Project Summer, \$25,000, 2010
10. Howard L. Blood Scholarship, \$4000, Summer 2010
11. Sigma Pi Sigma Physics Honor Society, April 2010
12. Vice-President for Research Fellowship, \$10,000, Fall 2009
13. NSF Student Travel Grant, \$2000, Summer 2009
14. Finalist Fulbright Scholarship, Spring 2009
15. Fontana Travel Award, \$375, December 2008
16. Best Picture, National Paddling Film Festival, Amateur Category, *Lemonade*, 2006

OUTREACH

See *Invited Lectures: Public* section above for more examples of outreach.

- **Tabletop PTA**, Sept 2017-Present
A table demonstration of how a pulsar timing array works using metronomes and smart phones.
- **Kamchatka Project Science Coordinator**, January 2009-2011
Outreach/Science coordinator for the Kamchatka Project, a National Geographic funded kayaking expedition to the Kamchatka Peninsula of far-east Russia.
- **Science Unwrapped Volunteer**, Jan 2009- 2011
Answer questions about black holes and falling into black holes as part of public interactions after astrophysics themed talks.

REFERENCES

- **Dr. Joey Key** *Post Doctoral Advisor*
Professor of Physics
University of Washington Bothell, Bothell, WA 98011
Phone: 425-352-5497 *email:* joey.key@uw.edu
- **Dr. Shane Larson** *Collaborator*
Research Associate Professor
Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA)
Northwestern University, Evanston, IL 60208
Phone: 847-467-4305 *email:* s.larson@northwestern.edu
- **Dr. Joseph Romano** *Post Doctoral Advisor*
Professor of Physics
Texas Tech University, Lubbock, TX 79409
Phone: 806-834-6522 *email:* joseph.d.romano@ttu.edu
- **Dr. James T. Wheeler** *PhD Advisor, Utah State University*
Associate Professor of Physics
Utah State University, Logan, UT 84321
Phone: 435-770-7601 *email:* jim.wheeler@usu.edu