Jeremiah Birrell

Current Position

Visiting Assistant Professor
Department of Mathematics
University of Arizona
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Research Interests

Broadly, my interests revolve around mathematical physics. Current and past research topics include:

- Stability properties, singular limits, and homogenization of stochastic differential equations.
- Computer aided proofs in dynamical systems.
- Astroparticle physics and cosmology in the Standard Model from the Electroweak era to the present day.
- Numerical methods for the relativistic Boltzmann equation, especially moving frame type methods utilizing non-classical orthogonal polynomials.

Education

Program in Applied Mathematics, University of Arizona

Ph.D. in Applied Mathematics, August 2014

- Dissertation: Non-equilibrium Aspects of Relic Neutrinos: From Freeze-out to the Present Day
- Advisor: Dr. Johann Rafelski, Department of Physics and Faculty Member of the Program in Applied Mathematics

Brigham Young University

B.S. in Physics, December 2007

- Minor in mathematics
- Summa Cum Laude

Research Experience

2015-Present — with J. Wehr, Department of Mathematics, U. of Arizona

- Singular limits of stochastic differential equations, including Hamiltonian systems and randomly perturbed geodesic flow on a Riemannian manifold.
- Nonequilibrium statistical mechanics and entropy production.

2010 - 2015 — with J. Rafelski, Department of Physics, U. of Arizona

- Spectral based numerical method for solving the Boltzmann equation and capturing reheating and emergent chemical non-equilibrium.
- Improved method for computing scattering integrals for electroweak processes involving electrons and neutrinos for use in Boltzmann solvers.
- Model independent characterization of the chemical non-equilibrium aspects of the relic neutrino distribution after freeze-out.
- General relativistic models of compact objects, including electroweak Bose-Fermi stars.

2010 — with J. Wehr, Department of Mathematics, U. of Arizona

- Noise induced stability of a family stochastic differential equations.

2010 with D. Glickenstein, Department of Mathematics, U. of Arizona
- Ricci flow of left invariant metrics on Lie groups.

Teaching Experience

Fall	2016	Lecturer, Discrete Structures
Spring	2016	Lecturer, Complex Variables
Fall	2015	Lecturer, First Semester Calculus
Fall	2012	Graduate Mentor for Applied Mathematics Ph.D Qualifying Exam
Fall	2011	Graduate Mentor for Applied Mathematics Ph.D Qualifying Exam
Spring	2011	Lecturer, Calculus Preparation
Fall	2010	Lecturer, College Algebra
Spring	2010	Lecturer, College Algebra
Fall	2009	Teaching Assistant, College Algebra

Service

2014-2015, 2015-2016 Admissions Committee Member for the University of Arizona Program in Applied Mathematics

Honors and Awards

2014	University of Arizona Program in Applied Mathematics Al Scott Prize and Lecture
2011-2014	National Defense Science and Engineering Graduate Fellowship
2012	University of Arizona Galileo Circle Scholar
2012	University of Arizona HE Carter Travel Award
2009-2010	University of Arizona S-STEM Fellowship
2003-2007	Brigham Young University Heritage Scholarship Recipient

Internships

Summer 2013	Graduate Mathematics Program, National Security Agency
Summer 2011	CERN, Geneva, Switzerland under Dr. Johann Rafelski

Graduate Coursework

- ❑ Real and Complex Analysis
- ❑ Functional Analysis
- ❑ Partial Differential Equations
- ❑ Numerical Linear Algebra
- ❑ Numerical ODEs
- ❑ Numerical PDEs
- ❑ Logic and Computability
- ❑ Algebraic Topology
- ❑ Differential Geometry
- ❑ Probability
- ❑ Stochastic Processes
- ❑ Quantum Mechanics
- ❑ General Relativity
- ❑ Particle Physics

Computer Skills

Experienced in C++, Java, MATLAB, Maple, and LaTeX

Publications

J. Birrell, S. Hottovy, G. Volpe, J. Wehr, Small Mass Limit of a Langevin Equation on a Manifold, *Annales Henri Poincaré*, 1 (2016). (Preprint arXiv:1604.04819)

J. Rafelski, J. Birrell, 4th International Conference on New Frontiers in Physics (ICNFP 2015) Kolymbari, Greece, August 23-30, 2015. (Preprint arXiv:1604.08689)

J. Birrell, A Posteriori Error Bounds for Two Point Boundary Value Problems: A Green's Function Approach, *Journal of Computational Dynamics* **2**, 143 (2015). (Preprint arXiv:1410.0785)

J. Rafelski, J. Birrell, Dynamical Emergence of the Universe into the False Vacuum, *J. Cosmol. Astropart. Phys.* **11**, 35 (2015). (Preprint arXiv:1510.05001)

J. Birrell, J. Rafelski, Proposal for Resonant Detection of Relic Massive Neutrinos, *Eur. Phys. J. C* **75**, 91 (2015). (Preprint arXiv:1402.3409)

J. Birrell, J. Rafelski, Quark-Gluon Plasma as the Possible Source of Cosmological Dark Radiation, *Phys. Lett. B* **741**, 77 (2015). (Preprint arXiv:1404.6005)

J. Birrell, C. T. Yang, J. Rafelski, Relic Neutrino Freeze-out: Dependence on Natural Constants, *Nucl. Phys. B* **890**, 481 (2015). (Preprint arXiv:1406.1759)

J. Birrell, J. Wilkening, J. Rafelski, Boltzmann Equation Solver Adapted to Emergent Chemical Non-equilibrium, *J. Comput. Phys.* **281**, 896 (2015). (Preprint arXiv:1403.2019)

J. Birrell, Non-Equilibrium Aspects of Relic Neutrinos: From Freeze-out to the Present Day, Ph.D. Dissertaton, arXiv:1409.4500, (2014)

J. Rafelski, J. Birrell, Traveling Through the Universe: Back in Time to the Quark-Gluon Plasma Era, *Journal of Physics: Conference Series* **509** (2014) 012014. (Preprint arXiv:1311.0075)

J. Birrell, C. T. Yang, P. Chen, J. Rafelski, Relic neutrinos: Physically consistent treatment of effective number of neutrinos and neutrino mass, *Phys. Rev. D* **89**, 023008 (2014). (Preprint arXiv:1212.6943)

J. Birrell, C. T. Yang, P. Chen, J. Rafelski, Fugacity and Reheating of Primordial Neutrinos, *Mod. Phys. Lett. A* **28**, 40, 1350188 (2013). (Preprint arXiv:1303.2583)

J. Rafelski, L. Labun, J. Birrell, Compact Ultra Dense Matter Impactors, *Phys. Rev. Lett.* **110**, 111102 (2013). (Preprint arXiv:1104.4572)

J. Birrell, J. Rafelski, Possibility of Electroweak Phase Transition at Low Temperature,Presented at 52nd Cracow School of Theoretical Physics: Astroparticle Physics in the LHC Era, Zakopane, Poland, (2012). (Preprint arXiv:1205.1011)

J. Birrell, D. P. Herzog, J. Wehr, Transition from ergodic to explosive behavior in a family of stochastic differential equations, *Stochastic Processes and their Applications* **122** (2012) 1519-1539. (Preprint arXiv:1105.2378)

Talks

Invited to 35th Annual Western States Meeting of Mathematical Physics, Caltech, Pasadena, California (February 12 - 13, 2017).

Small Mass Limit of Noisy Particle Motion on a Manifold, Great Lakes Mathematical Physics Meeting, Michigan State University, East Lansing, Michigan (June 18, 2016).

Small Mass Limit of Noisy Particle Motion on a Manifold, Mathematical Physics and Probability Seminar, University of Arizona, Tucson, Arizona (March 23, 2016).

Revisiting the Freeze-out of Relic Neutrinos, Al Scott Prize and Lecture, Applied Math Colloquium, University of Arizona, Tucson, Arizona (May 2, 2014).

Physically consistent treatment of effective number of relic neutrinos and neutrino mass, APS April Meeting 2014, Savannah, Georgia (April 7, 2014).

General Relativistic Kinetic Theory and Neutrino Freeze-out, Mathematical Physics Seminar, University of Arizona, Tucson, Arizona (December 4, 2013).

Fugacity and Reheating of Primordial Neutrinos, APS April Meeting 2013, Denver, Colorado (April 13, 2013).

General Relativistic Kinetic Theory, Modeling and Computation Seminar, University of Arizona, Tucson, Arizona (October 4, 2012).

Strong Electric Fields in Electroweak Stars, 13th Marcel Grossman Meeting on Recent Developments in Theoretical and Experimental General Relativity, Astrophysics, and Relativistic Field Theories, Stockholm University, Sweden, (July 3, 2012).

Model of a Strong First Order Electroweak Phase Transition, 52nd Cracow School of Theoretical Physics: Astroparticle Physics in the LHC Era, Zakopane, Poland (May 20, 2012).

Bose-Fermi Stars, Mathematical Physics Seminar, University of Arizona, Tucson, Arizona (November 16, 2011).

Boson Stars in General Relativity, Workshop on Recent Progress of Wave Processes in Nature, University of Arizona, Tucson, Arizona (October 7, 2011).

Nonlinear Drude plasma model for ultra-short pulse simulation, Modeling and Computation Seminar, University of Arizona, Tucson, Arizona (September 24, 2009).