Jeremiah Birrell

CURRENT POSITION

TRIPODS Institute for Theoretical Foundations of Data Science: Postdoc
University of Massachusetts Amherst
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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 INTERESTS

My interests revolve around probability, stochastic analysis, and mathematical physics. Current and past research topics include:

- Information theoretic methods for generative adversarial networks (GANs)
- Statistical learning of information divergences
- Uncertainty quantification and information theoretic approaches to distributional robustness bounds for stochastic systems.
- Stability properties, singular limits, and homogenization of stochastic differential equations.
- Kinetic theory, focusing on spectral methods for simulating the general-relativistic Boltzmann equation.

PREPRINTS

J. Birrell, Distributionally Robust Variance Minimization: Tight Variance Bounds over f-Divergence Neighborhoods, (2020). Preprint: arXiv:2009.09264

J. Birrell, M.A. Katsoulakis, Y. Pantazis, Optimizing variational representations of divergences and accelerating their statistical estimation, (2020). Preprint: arXiv:2006.08781

J. Birrell, L. Rey-Bellet, Concentration inequalities and performance guarantees for hypocoercive MCMC samplers, (2019). Preprint: arXiv:1907.11973

JOURNAL PUBLICATIONS

J. Birrell, P. Dupuis, M. A. Katsoulakis, L. Rey-Bellet, Y. Pantazis, (f, Γ)-Divergences: Interpolating between f-Divergences and Integral Probability Metrics, to appear in *Journal of Machine Learning Research* (2022). Preprint: arXiv:2011.05953

J. Birrell, P. Dupuis, M.A. Katsoulakis, L. Rey-Bellet, J. Wang, Variational Representations and Neural Network Estimation for Rényi Divergences, *SIAM Journal on Mathematics of Data Science*, 3:4, 1093-1116 (2021). (Preprint: arXiv:2007.03814)

J. Birrell, M. Katsoulakis, L. Rey-Bellet, Quantification of Model Uncertainty on Path-Space via Goal-Oriented Relative Entropy, *ESAIM: M2AN* 55 1, 131-169 (2021). (Preprint: arXiv:1906.09282)

J. Birrell, L. Rey-Bellet, Uncertainty Quantification for Markov Processes via Variational Principles and Functional Inequalities *SIAM/ASA Journal on Uncertainty Quantification* 8(2), 539-572 (2020). (Preprint: arXiv:1812.05174)

J. Birrell, J. Wehr, Langevin Equations in the Small-Mass Limit: Higher-Order Approximations. *Ann. Henri Poincaré* 21(6), 1765-1811 (2020). (Preprint: arXiv:1809.01724)

J. Birrell, Entropy Anomaly in Langevin-Kramers Dynamics with a Temperature Gradient, Matrix Drag, and Magnetic Field, *J. Stat. Phys.* 173(6), 1549 (2018). (Preprint: arXiv:1709.06981)

J. Birrell, J. Wehr, Phase Space Homogenization of Noisy Hamiltonian Systems, *Ann. Henri Poincaré* **19**: 1081 (2018). (Preprint: arXiv:1705.05004)

J. Birrell, J. Wehr, Homogenization of Dissipative, Noisy, Hamiltonian Dynamics, *Stochastic Processes and their Applications* **128**: 2367 (2018). (Preprint: arXiv:1608.08194)

J. Birrell, S. Hottovy, G. Volpe, J. Wehr, Small Mass Limit of a Langevin Equation on a Manifold, *Ann. Henri Poincaré* **18**: 707 (2017). (Preprint: arXiv:1604.04819)

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

Book Chapters

J. Birrell and J. Wehr, *A homogenization theorem for Langevin systems with an application*

to Hamiltonian dynamics, in Sojourns in Probability Theory and Statistical Physics - I (V. Sidoravicius, ed.), (Singapore), pp. 89–122, Springer Singapore, (2019). (Preprint: arXiv:1707.02884)

Conference Proceedings

J. Rafelski, J. Birrell, The Hot Hagedorn Universe, *EPJ Web Conf.* **126**: 03005 (2016). (Preprint: arXiv:1604.08689)

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

Courses Taught as Primary Instructor

Spring	2020	UMass Amherst, Applied Linear Algebra
Fall	2019	UMass Amherst, Nonlinear Dynamics and Chaos
Spring	2019	UMass Amherst, Applied Linear Algebra
Fall	2018	UMass Amherst, Complex Variables
Spring	2018	UMass Amherst, Calculus III
Fall	2017	UMass Amherst, Nonlinear Dynamics and Chaos
Spring	2017	University of Arizona, Discrete Structures
Fall	2016	University of Arizona, Discrete Structures
Spring	2016	University of Arizona, Complex Variables
Fall	2015	University of Arizona, First Semester Calculus
Spring	2011	University of Arizona, Calculus Preparation
Fall	2010	University of Arizona, College Algebra
Spring	2010	University of Arizona, College Algebra

Service

2014-2015, 2015-2016, 2016-2017	Admissions Committee Member for the University of Arizona Program in Applied Mathematics
2011, 2012	Graduate Mentor for University of Arizona Applied Mathematics Ph.D Qualifying Exam

Referee for the Journals:

SIAM Journal on Applied Mathematics
Stochastic Processes and their Applications
SIAM/ASA Journal on Uncertainty Quantification
Journal of Statistical Mechanics: Theory and Experiment
Proceedings of the Royal Society A

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

Computer Skills

Python, Tensorflow, MATLAB, Java

Talks

(f, Γ)-*Divergences: Interpolating between Wasserstein Metrics and f-Divergences*, Northeast Probability Seminar, November 20, 2020.

Invited to speak at the SIAM Conference on Mathematical Aspects of Materials Science (MS20), Bilbao, Spain, May 18-22, 2020 (cancelled due to Covid-19).

Invited to speak at the AMS Special session on Probability in Dynamical Systems of Physical Origin, AMS Spring Eastern Sectional Meeting, Tufts University, March 21-22, 2020 (cancelled due to Covid-19).

Information-Theoretic Approaches to Distributional Robustness, Stochastics Seminar, University of Utah, November 22, 2019 (Invited Talk).

Small Mass Limit of Noisy Inertial Particle Dynamics: Homogenization, Instantaneous Equilibration, and Entropy Production, Probability Seminar, Boston University, October 17, 2019 (Invited Talk).

Uncertainty Quantification via Variational Principles: Applications to Hitting Times, 121st Statistical Mechanics Conference, Rutgers University, May 13, 2019.

Langevin Equations in the Small-Mass Limit: Higher-Order Approximations, Phase-Space Homogenization, and Entropy Production, Northeast Probability Seminar, Courant Institute of Mathematical Sciences, November 16, 2018.

Uncertainty Quantification via Variational Principles and Functional Inequalities, Functional Inequalities in Probability Workshop, University of Connecticut, November 2, 2018.

Small Mass Limit of Noisy Inertial Particle Dynamics: Homogenization, Instantaneous Equilibration, and Entropy Production, Mathematical Physics and Probability Seminar, University of Arizona, February 21, 2018 (Invited Talk).

Small Mass Limit of Noisy Inertial Particle Dynamics: Homogenization, Instantaneous Equilibration, and Entropy Production, Applied Analysis and Computation Seminar, University of Massachusetts Amherst, September 19, 2017.

Small Mass Limit of Noisy Inertial Particle Dynamics: Homogenization and Instantaneous Equilibration, Mathematical Physics and Probability Seminar, University of Arizona, April 19, 2017.

Small Mass Limit of a Langevin Equation on a Manifold, 35th Annual Western States Meeting of Mathematical Physics, Caltech, February 12 - 13, 2017.

Homogenization of Dissipative, Noisy, Hamiltonian Dynamics, Mathematical Physics and Probability Seminar, University of Arizona, October 5, 2016.

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

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

Revisiting the Freeze-out of Relic Neutrinos, Al Scott Prize and Lecture, Applied Math Colloquium, University of 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, 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, 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, November 16, 2011.

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

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