

Ryan Gregory James

CONTACT INFORMATION

Physics Department
University of California, Davis
One Shields Avenue, Davis CA 95616

rgjames@ucdavis.edu
<http://csc.ucdavis.edu/~rgjames/>
(530) 341-2048

RESEARCH INTERESTS

complex systems, natural computation, information theory, critical phenomena, combinatorics, formal language theory & automata theory, symbolic dynamics, physics of information

EDUCATION

University of California, Davis, Davis, California USA

Ph.D., Physics, September 2013

- Dissertation Topic: “Measures and Metrics of Information Processing in Complex Systems: A Rope of Sand”
- Advisor: James P. Crutchfield

M.S., Physics, May 2009

California State University, Long Beach, Long Beach, California USA

B.S., Physics, May 2007

- Department Honors

B.S., Computer Science, May 2007

PROFESSIONAL MEMBERSHIPS

- American Physical Society
- UC Davis Data Science Initiative
- Software & Data Carpentry

SERVICE

ORGANIZER

Dynamics of Learning group meetings

Fall 2012 - Fall 2013, Fall 2014 - Present

JOURNAL REFEREE

- Advances in Complex Systems
- Chaos: An Interdisciplinary Journal of Nonlinear Science
- Complexity
- Entropy
- Journal of Statistical Mechanics
- Nature Communications
- Physical Review E
- Physical Review Letters

**ACADEMIC
EXPERIENCE**

Software & Data Carpentry

Instructor

July 2018 - Present

University of California, Davis: Davis, California USA

Postdoctoral Researcher

September 2014 - Present

Investigated information-theoretic nature of information transfer and multivariate dependence. Quantified collective behavior utilizing information theory in lattice models. Developed methods of constructing minimal generative models of stochastic processes. Addressed the decomposition of multivariate information in to interpretable components.

September 2016 - Present

Developed unsupervised methods of feature extraction and coherent structure detection on massive multivariate data sets in collaboration with NERSC. This work is intended to run at scale on the Cori supercomputer, utilizing $\approx 100,000+$ cores and processing $\approx 100+$ terabytes of data.

University of Colorado at Boulder: Boulder, Colorado USA

Research Associate

September 2013 - August 2014

Performed research into the predictability of deterministic dynamical systems, with emphasis on predicting statistics of CPU dynamics. Developed new model parameter selection criteria based on information-theoretic concerns. Investigated the information-theoretic properties of climate change via chemical histories embedded in ice cores.

Santa Fe Institute: Santa Fe, New Mexico USA

Guest Lecturer, Complexity Sciences Summer School

June 2011

June 2012

June 2014

June 2018

Conducted lectures and designed & administered computer labs on information theory and measures of complexity.

University of California, Davis: Davis, California USA

Graduate Student Researcher

Spring 2009 - Summer 2013

Performed novel research into how complex systems store, process and transform information. Developed algorithms and measures based on formal language theory, automata theory, statistical physics, information theory, and in particular esoteric measures of shared information, and implemented these in the Python programming language.

Lecturer

Fall 2012

Wrote and presented lectures for the Physics 7 Series.

Guest Lecturer, Developer

Spring 2012

Spring 2013

Spring 2015

Spring 2016

Spring 2017

Spring 2018

Wrote and presented lectures to Dr. Crutchfield's graduate physics class on natural computation and self organization. Configured a comprehensive online suite of tools for student assignments, projects,

and research. This course won the 2013 SIAM Teaching Dynamical Systems award.

Associate Instructor

Fall 2009
Winter 2012

Updated and refined teaching lessons and lab activities, shared administrative responsibilities with course lecturer including writing examination material, guided all teaching assistants.

Teaching Assistant

September 2007 - August 2009

Lead “discussion-lab” sessions for the innovative Physics 7 Series.

PUBLICATIONS

Ryan G. James, Jeffrey Emenheiser, James P. Crutchfield “Unique Information and Secret Key Agreement” *Entropy* 21 (1), 12 (2019).

Ryan G. James, Jeffrey Emenheiser, James P. Crutchfield “Unique Information via Dependency Constraints” *Journal of Physics A: Mathematical and Theoretical* 52 (1), 014002 (2018).

Hiroshi Ashikaga, **Ryan G. James** “Inter-Scale Information Flow as a Surrogate for Downward Causation That Maintains Spiral Waves” *Chaos: An Interdisciplinary Journal of Nonlinear Science* 28 (7), 075306 (2018).

Martin Hilbert, **Ryan G. James**, Teresa Gil-Lopez, Ke Jiang, Yining Zhou “The Complementary Importance of Static Structure and Temporal Dynamics in Teamwork Communication” *Human Communication Research* (2018).

Ryan G. James, Christopher J. Ellison, James P. Crutchfield “*dit*: a Python package for discrete information theory” *Journal of Open Source Software* 3 (25), 738 (2018).

Joshua Ruebeck, **Ryan G. James**, John R. Mahoney, James P. Crutchfield “Prediction and Generation of Binary Markov Chains: Can Finite-State Fox Catch Markov Mouse?” *Chaos: An Interdisciplinary Journal of Nonlinear Science* 28 (1), 013109 (2018).

Ryan G. James, James P. Crutchfield “Multivariate Dependencies Beyond Shannon Information” *Entropy* 19 (10), 531 (2017).

Ryan G. James “Information Trimming: Sufficient Statistics, Mutual Information, and Predictability from Effective Channel States” *Physical Review E* 95 (6) 060102 (2017)

Hiroshi Ashikaga, **Ryan G. James** “Hidden Structures of Information Transport Underlying Spiral Wave Dynamics” *Chaos: An Interdisciplinary Journal of Nonlinear Science* 27 (1), 013106 (2017)

Vikram Vijayaraghavan, **Ryan G. James**, James P. Crutchfield “Anatomy of a Spin: The Information-Theoretic Structure of Classical Spin Systems” *Entropy* 19 (5) 214 (2017).

Ryan G. James, Nix Barnett, James P. Crutchfield “Information Flows? A Critique of Transfer Entropies” *Physical Review Letters* 116 (2016) 238701.

Joshua Garland, **Ryan G. James**, Elizabeth Bradley “Leveraging information storage to select forecast-optimal parameters for delay-coordinate reconstructions” *Physical Review E* 93, 022221 (2016).

Pooneh M. Ara, **Ryan G. James**, James P. Crutchfield. “The Elusive Present: Hidden Past and Future Dependency and Why We Build Models” *Physical Review E* 93, 022143 (2016).

Joshua Garland, **Ryan G. James**, and Elizabeth Bradley. “Model-Free Quantification of Time-Series

Predictability” *Physical Review E* 90, 052910 (2014).

Ryan G. James, Korana Burke, and James P. Crutchfield. “Chaos Forgets and Remembers: Measuring Information Creation, Destruction, and Storage” *Physics Letters A*, Volume 378, Issues 30-31 (2014).

Ryan G. James, John R. Mahoney, Christopher J. Ellison, and James P. Crutchfield. “Many Roads to Synchrony: Natural Time Scales and Their Algorithms” *Physical Review E* 89, 042135 (2014).

Virgil Griffith, Edwin K. P. Chong, **Ryan G. James**, Christopher J. Ellison, and James P. Crutchfield. “Intersection Information based on Common Randomness” *Entropy* 16, 1985-2000 (2014).

John R. Mahoney, Christopher J. Ellison, **Ryan G. James**, and James P. Crutchfield. “How Hidden are Hidden Processes? A Primer on Crypticity and Entropy Convergence.” *Chaos: An Interdisciplinary Journal of Nonlinear Science* 21, 037112 (2011).

Ryan G. James, Christopher J. Ellison, and James P. Crutchfield. “Anatomy of a Bit: Information in a Time Series Observation.” *Chaos: An Interdisciplinary Journal of Nonlinear Science* 21, 037109 (2011).

Christopher J. Ellison, John R. Mahoney, **Ryan G. James**, James P. Crutchfield, and Jörg Reichardt. “Information Symmetries in Irreversible Processes.” *Chaos: An Interdisciplinary Journal of Nonlinear Science* 21, 037107 (2011).

James P. Crutchfield, Christopher J. Ellison, **Ryan G. James**, and John R. Mahoney. “Synchronization and Control in Intrinsic and Designed Computation: An Information-Theoretic Analysis of Competing Models of Stochastic Computation.” *Chaos: An Interdisciplinary Journal of Nonlinear Science* 20, 037105 (2010).

Chuheee Kwon, Jeremy L. Young, **Ryan G. James**, George A. Levin, Timothy J. Haugan, and Paul N. Barnes. “Effects of local artificial defects in multifilamentary coated conductors with patterned links.” *Journal of Applied Physics* 101, 083908 (2007).

Chuheee Kwon, Jeremy L. Young, **Ryan G. James**, George A. Levin, Timothy J. Haugan, and Paul N. Barnes. “Local Current Transport and Current Sharing Between Filaments in Striated Coated Conductors With Artificial Defects.” *IEEE Transactions On Applied Superconductivity* 17, 3191-3194 (2007).

REFEREED PROCEEDINGS

Joshua Garland, Tyler R. Jones, Elizabeth Bradley, **Ryan G. James**, James W. C. White “A First Step Toward Quantifying the Climate’s Information Production Over the Last 68,000 Years” IDA 2016: The 15th International Symposium on Intelligent Data Analysis, Stockholm, Sweden, October 13th 2016

PREPRINTS

James P. Crutchfield, **Ryan G. James**, Sarah Marzen, Dowman P. Varn. “Understanding and Designing Complex Systems: Response to “A framework for optimal high-level descriptions in science and engineering—preliminary report”” <http://arxiv.org/abs/1412.8520>

Hiroshi Ashikaga, Konstantinos N. Aronis, Susumu Tao, **Ryan G. James** “Causal Scale Shift Associated with Phase Transition to Human Atrial Fibrillation” <https://arxiv.org/abs/1804.10828>.

Ryan G. James, Bahti Zakirov, Blanca Daniella Masante Ayala, James P. Crutchfield “Modes of Information Flow” <https://arxiv.org/abs/1808.06723>.

Ryan G. James, Jeffrey Emenheiser, James P. Crutchfield “A Perspective on Unique Information: Directionality, Intuitions, and Secret Key Agreement” <https://arxiv.org/abs/1808.08606>.

INVITED TALKS

Modes of Information Flow International Conference on Complex Systems, Boston, Massachusetts, July 24th 2018

Modes of Information Flow Data Science Initiative Network Sciences Working Group Seminar, UC Davis, Davis, California, January 17th 2018

Multivariate Dependence Beyond Shannon Information ~or~ How the Heck Can Three Variables Interact Anyway?! 2017 SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah, May 26th 2017

Multivariate Dependence and Quantifying Interactions NetControl MURI Annual Review Meeting 2016, CalTech, Pasadena, California, December 7th 2016

Multivariate Dependence Beyond Shannon Information UC Davis Neuroscience / Data Analytics Seminar, Center for Mind and Brain, UC Davis, Davis, California, October 31st 2016

New Horizons in Information Theory 6th Annual Davis Mathematics Conference, Davis, California, November 10th 2015

The Unpredictable, the Predetermined, and the Postdetermined Unfold Together AI Colloquium, University of Southern California Information Sciences Institute, Marina Del Ray, California, November 3rd 2015

The Unpredictable, the Predetermined, and the Postdetermined Unfold Together CSULB Physics Colloquium, Long Beach, California, November 2nd 2015

New Horizons in Information Theory Conference on Complex Systems 2015, Tempe, Arizona, September 30th 2015

Chaos Forgets and Remembers: A Rope of Sand Learning, Information Theory, and Non-Equilibrium Thermodynamics seminar series, Berkeley, California, September 18th 2015

Degrees of Information Processing in Chaotic Dynamical Systems SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah, May 19th 2015

What is Redundancy?: A Survey of Recent Results Cognitive Lunch, University of Indiana at Bloomington, Bloomington, Indiana, February 26th 2014

Chaos Forgets and Remembers Dynamical/Complex Systems Seminar, University of Colorado at Boulder, Boulder, Colorado, October 3rd 2013

Forgetting and Remembering in Chaotic Dynamical Systems 2013 International Symposium on Nonlinear Theory and its Applications, Santa Fe, New Mexico, September 9th 2013

**CONTRIBUTED
TALKS**

Modes of Information Flow UC Davis Postdoctoral Research Symposium 2018, April 23rd 2018

More Is Different: Modes of Information Flow APS Far West Section Meeting 2017, Merced, California, November 3rd 2017

Quantifying Unique Information Using Dependencies Conference on Complex Systems 2017, Cancun, Mexico, September 20th 2017

Multivariate Dependence Beyond Shannon Information Conference on Complex Systems 2017, Cancun, Mexico, September 18th 2017

Multivariate Dependence Beyond Shannon Information ~or~ How the Heck Can Three Variables Interact Anyway?! UC Davis Postdoctoral Research Symposium 2017, April 12th 2017

Multivariate Dependence Beyond Shannon Information Dynamics Days 2017, Silver Springs, Maryland, January 7th 2017

Multivariate Dependence Beyond Shannon Information APS Far West Chapter Meeting, Davis, California, October 28th 2016

Anatomy of a Spin: The Information-Theoretic Structure of Classical Spin Systems APS March Meeting, Baltimore, Maryland, March 17th 2016

Anatomy of a Spin: The Information-Theoretic Structure of Classical Spin Systems APS Far West Section Meeting, Long Beach, California, October 30th 2015

Not All Generating Partitions are Created Equal Conference on Complex Systems 2015, Tempe, Arizona, September 29th 2015

Forgetting and Remembering in Chaotic Dynamical Systems Dynamics Days 2013, Denver, Colorado, January 4th 2013

Anatomy of a Bit: Information-Theoretic Analysis of Stochastic Processes European Conference on Complex Systems 2012, Brussels, Belgium, September 7th 2012

Information Theory for Tralfamadorians: The Anatomy of a Bit: A Rope of Sand 12th Experimental Chaos and Complexity Conference, Ann Arbor, Michigan, May 19th 2012

POSTERS

Modes of Information Flow Dynamics Days 2018, Denver, Colorado, January 6th 2018

Information Theory for Tralfamadorians: The Anatomy of a Bit Interdisciplinary Graduate and Professional Student Symposium, Davis, California, April 26th 2012

Information Theory for Tralfamadorians: The Anatomy of a Bit Dynamics Days 2012, Baltimore, Maryland, January 5th 2012

MEDIA

Binder, P.-M., and R. M. Pipes. "Applied mathematics: How chaos forgets and remembers." *Nature* 510.7505 (2014): 343-344.

"Predicting unpredictability: Information theory offers new way to read ice cores" *ScienceDaily*, December 6th 2016, <https://www.sciencedaily.com/releases/2016/12/161206125325.htm>

"Pattern discovery over pattern recognition—new way for computers to see" *PhysOrg*, April 19th

2017, <https://phys.org/news/2017-04-pattern-discovery-recognitionnew.html>

ACKNOWLEDGEMENTS

S. DeDeo, R. X. Hawkins, S. Klingenstein, T. Hitchcock. “Bootstrap methods for the empirical study of decision-making and information flows in social systems” *Entropy*. 2013 Jun 5;15(6):2246-76.

N. Bertschinger, J. Rauh, E. Olbrich, J. Jost, and N. Ay. “Quantifying Unique Information” *Entropy* 2014 Apr 15;16(4):2161-83

S. Klingenstein, T. Hitchcock, S. DeDeo. “The civilizing process in London’s Old Bailey” *Proceedings of the National Academy of Sciences*. 2014 Jul 1;111(26):9419-24.

V. Griffith, T. Ho. “Quantifying redundant information in predicting a target random variable” *Entropy*. 2015 Jul 2;17(7):4644-53.

D. Darmon, E. Omodei, J. Garland. “Followers are not enough: A multifaceted approach to community detection in online social networks” *PloS one*. 2015 Aug 12;10(8):e0134860.

M. M. Wilde. “Squashed entanglement and approximate private states” *Quantum Information Processing*. 2016 Nov 1;15(11):4563-80.

R. A. Ince. “The Partial Entropy Decomposition: Decomposing multivariate entropy and mutual information via pointwise common surprisal” <https://arxiv.org/abs/1702.01591>

B. Allen, B. Stacey, Y. Bar-Yam. “Multiscale Information Theory and the Marginal Utility of Information” *Entropy*. MDPI AG; 2017 Jun 13;19(6):273

R. A. Ince. “Measuring multivariate redundant information with pointwise common change in surprisal” *Entropy*. 2017 Jun 29;19(7):318.

J. W. Kay, R. A. Ince “Exact partial information decompositions for Gaussian systems based on dependency constraints” <https://arxiv.org/abs/1803.02030>

J. W. Kay, W. A. Phillips “Contrasting information theoretic decompositions of modulatory and arithmetic interactions in neural information processing systems” <https://arxiv.org/abs/1803.05897>

MENTORING

David Gier: UC Davis NSF Research Experience for Undergraduates 2015

Joshua Ruebeck: UC Davis NSF Research Experience for Undergraduates 2016

Bahti Zakirov: UC Davis NSF Research Experience for Undergraduates 2017

Crystal Lee: Visualization of Multivariate Information undergraduate research project, 2019

SOFTWARE

dit: <http://www.github.com/dit/dit>

A python library for the study of discrete information theory. Implements a wide variety of information measures relevant to scientific and engineering problems.

cmpy: *hosted privately*

A python library for the study of computational mechanics. Object classes for many types of hidden Markov models, and algorithms to study their temporal information dynamics.

REFERENCES

James P. Crutchfield, Professor, Department of Physics and Complexity Sciences Center, University

of California, Davis
chaos@cse.ucdavis.edu

Raissa M. D'Souza, Professor, Department of Computer Science, Department of Mechanical and Aerospace Engineering, and Complexity Sciences Center, University of California, Davis
raissa@cse.ucdavis.edu

Hiroshi Ashikaga, M.D., Ph.D., Assistant Professor of Medicine, Director: Laboratory of Unconventional Electrophysiology, Johns Hopkins School of Medicine hashikal@jhmi.edu

David J. Webb Department of Physics, University of California, Davis
webb@physics.ucdavis.edu (concerns teaching)