

## Sarah E. Marzen

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### CONTACT INFORMATION

W. M. Keck Science Department    *Voice:* (202) 445-3243  
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Claremont, CA 91711 USA          *WWW:* sarahmarzen.com

### EDUCATION

**University of California, Berkeley**, Berkeley, CA, USA

Ph.D., Physics, May 2016

- Dissertation Topic: “Bio-inspired problems in rate-distortion theory”
- Advisor: Michael R. DeWeese

#### Summer schools

Machine Learning Summer School, 2013  
Santa Fe Institute Complex Systems School, 2014

**California Institute of Technology**, Pasadena, CA, USA

B.S., Physics, May 2011

### CURRENT FUNDING

Co-PI, **Templeton Foundation**

Project: Grokking the Voices of the Deep—Detecting Bioacoustic Signatures of Cetacean Intelligence through Semantic Information Theory

Amount: ~ \$250,000

Period of Performance: 09/01/2021-08/31/2023

PI, **Air Force Office of Scientific Research**, Computational and Cognitive Sciences

Project: ”Minimal Models of Sensory Prediction”

Amount: ~ \$600,000

Period of Performance: 08/2019-08/2022

### PROFESSIONAL AFFILIATIONS

Society for Industrial and Applied Mathematics, American Physical Society, Sigma Xi

### ACADEMIC EXPERIENCE

**Assistant Professor of Physics**, W. M. Keck Science Department, Claremont, CA

August 2019 - present

**Postdoctoral Fellow**, MIT, Cambridge, MA

Collaborated with Professor Nikta Fakhri and Professor Jeremy England          2016 - August 2019

**Seminar XL/LE Facilitator**, MIT, Cambridge, MA

February 2018 - May 2018, October 2018 - present

**Graduate Researcher**, U.C. Berkeley, Berkeley, CA

Advised by Professor Michael R. DeWeese          2011 - 2016

**Teaching Assistant** for Professor James Crutchfield, U. C. Davis, Davis, CA

Natural Computation and Self-Organization, a graduate-level course with ~ 30 students    Fall 2015

**Teaching Assistant** for Professor Rob Phillips, Caltech, Pasadena, CA

Physical Biology of the Cell (APh161), graduate-level course with ~ 30 students    Winter 2010

Freshman biology laboratory (Bi1x), with ~ 20 students    Spring 2010

**Research Assistant** to Professor Rob Phillips, Caltech, Pasadena, CA

Studied cooperativity in ligand-receptor binding models as Class of '52 SURF Fellow Summer 2010

Studied information-theoretic non-equilibrium statistical mechanical models as Amgen Scholar Summer 2009

**Research Assistant** to Professor Tom Tombrello, Caltech, Pasadena, CA

Studied simulation and fabrication of nanolasers as Physics 11 Research Fellow Summer 2008

**Research Assistant** to Dr. James Ellenbogen, MITRE Corporation, McLean, VA

Intern in MITRE Nanosystems Student Program Summers 2004-2007

HONORS, AWARDS  
AND SERVICE

**Mary W. Johnson Faculty Scholarship Award** 2022

**American Physical Society, Division of Biological Sciences** Executive Committee 2022

**Aspen Workshop co-organizer** 2022

**Entropy Topic Advisory Board** 2021

**MIT Kauffman Teaching Certificate Program** 2018

**MIT Physics of Living Systems Fellowship** 2016

Financial support for up to three years of postdoctoral fellowship

**Fellowship** from Ling-Lie Chau Excellence Award 2015

**Reviewer** for PLoS Computational Biology, Physics Review Research, Nature Physics, Frontiers in Computational Neuroscience, New Journal of Physics, Science Advances, Journal of Theoretical Biology, Advances in Complex Systems, Entropy, Bulletin of Mathematical Biology, Applied Sciences, Information, Mathematics, Sensors, and Physics Letters A 2014 -

**National Science Foundation Graduate Research Fellowship** in Biophysics 2011

Financial support for three years of graduate school

**U.C. Berkeley Chancellor's Fellowship** 2011

Financial support for two years of graduate school

**Haren Lee Fisher Memorial Award** 2010

Awarded to one junior at Caltech for excellence in physics

**Caltech Admissions Committee** member and blogger 2010

**Physics 11 Research Fellowship** 2008

Freshman-only research fellowship awarded to top six freshman applicants

**John Stauffer Merit Award** 2008

One of ~ 50 Caltech students to receive a merit award

**Caltech Tech News and Copy Editor** 2008-2011

**Caltech Axline Award** 2007-2011

Merit scholarship that provides free tuition, room, and board

**Intel Science Talent Search Finalist** 2007  
Hydrophobic hydration model chosen as one of the top 40 science fair projects in the United States

**U.S. Physics Team finalist** 2005, 2007  
Chosen as one of 24 students in United States to train for International Physics Olympiad

PUBLICATIONS

C. Tyler\*, J. Monroy and **S. Marzen**. “Mathematically modelling prey-catching behavior of the tomato frog”, *Spora* 8, 1-6 (2022).

**S. Marzen** and J. P. Crutchfield. “Probabilistic deterministic finite automata and recurrent networks, revisited”, *Entropy* 24 (1), 90 (2022)

**S. Marzen**. “Choosing dynamical systems that predict weak input”, *Physical Review E* 102 (2021)

B. Arul\*, D. Lee\*, and **S. Marzen**. “A proposed probabilistic method for distinguishing between delusions and other environmental judgements, with applications to psychotherapy”, *Frontiers in Psychology* (2021)

A. Duran\* and **S. Marzen**. “Not so optimal: The evolution of mutual information in potassium voltage-gated channels”, *bioRxiv:10.1101* and submitted (2021)

A. Hsu\* and **S. Marzen**. “Time cells might be optimized for predictive capacity, but not for redundancy reduction or memory capacity”, *Physical Review E* 102 (2020)

W. Zhong, J. M. Gold, **S. Marzen**, J. L. England, and N. Y. Halpern. “Machine learning outperforms thermodynamics in measuring how well a many-body system learns a drive”, *Scientific Reports* 11, 9333 (2021).

**S. Marzen** and J. P. Crutchfield. “Inference, prediction, and entropy rate estimation in continuous-time, discrete-event processes”, submitted (2020)

A. Uppal\*, V. Ferdinand, and **S. Marzen**. “Inferring an observer’s strategy in sequence learning experiments”, *Entropy* 22(8), 896 (2020). Chosen as a Featured Article for a Special Issue on Social Processes.

M. Razo-Mejia, **S. Marzen**, G. Chure, R. Taubman\*, M. Morrison, and R. Phillips. “First-principles prediction of the information processing capacity of a simple genetic circuit”, *Physical Review E* 102, 022404 (2020). Chosen as an Editor’s Suggestion.

**S. Marzen** and J. P. Crutchfield. “Prediction and Dissipation in Nonequilibrium Molecular Sensors: Conditionally Markovian Channels Driven by Memoryful Environments”, *Bulletin of Mathematical Biology* 82, 25 (2020)

**S. Marzen**. “Novelty detection improves reinforcement learning in fluctuating, partially observable environments”, *Journal of Theoretical Biology* 477, 44-50 (2019)

**S. Marzen**. “Intrinsic computation of a Monod-Wyman-Changeux molecule”, *Entropy* 20 (8), 599 (2018)

**S. Marzen**. “Infinitely large, randomly wired sensors cannot predict their input unless they are close to deterministic”, *PLoS ONE* 13 (8), e0202333 (2018)

**S. Marzen** and J. P. Crutchfield. “Optimized bacteria are environmental prediction engines”, *Physical Review E* 98, 012408 (2018)

**S. Marzen.** “Difference between memory and prediction in linear recurrent networks”, *Physical Review E* 96, 032308 (2017)

**S. Marzen** and J. P. Crutchfield. “Structure and randomness of continuous-time discrete-event processes”, *Journal of Statistical Physics* 169 (2) 303-315 (2017)

**S. Marzen** and J. P. Crutchfield. “Nearly maximally predictive features and their dimensions”, *Physical Review E* 95, 051301(R) (2017)

**S. Marzen** and S. DeDeo. “The evolution of lossy compression”, *Journal of the Royal Society Interface* 14 (2017)

**S. Marzen** and J. P. Crutchfield. “Informational and causal architecture of continuous-time renewal processes”, *Journal of Statistical Physics* 168 (1) 109-127 (2017)

C. Hillar and **S. Marzen.** “Revisiting perceptual distortion for natural images: mean discrete structural similarity index”, *Data Compression Conference* (2016)

**S. Marzen** and S. DeDeo. “Weak universality in sensory tradeoffs”, *Physical Review E* 94, 060101(R) (2016)

A. Goudarzi, **S. Marzen**, P. Banda, G. Feldman, M. R. Lakin, C. Teuscher, and D. Stefanovic. “Memory and information processing in recurrent neural networks”, submitted (2016)

**S. Marzen** and J. P. Crutchfield. “Predictive rate-distortion for infinite-order Markov processes”, *Journal of Statistical Physics* 163 (6), 1312-1338 (2016)

**S. Marzen** and J. P. Crutchfield. “Statistical Signatures of Structural Organization: The case of long memory in renewal processes”, *Physics Letters A* 380 (17), 1517-1525 (2016)

**S. Marzen**, M. R. DeWeese and J. P. Crutchfield. “Time resolution dependence of spike train information measures”, *Frontiers in Computational Neuroscience* 9 (2015)

J. P. Crutchfield and **S. Marzen.** “Signatures of Infinity: Nonergodicity in Prediction, Complexity, and Learning”, *Physical Review E* 91, 050106(R) (2015). Selected as an Editor’s Suggestion.

J. P. Crutchfield, R. G. James, **S. Marzen**, and D. P. Varn. “Understanding and Designing Complex Systems: Response to ‘A framework for optimal high-level descriptions in science and engineering—preliminary report’”, arXiv:1412.8520 [cond-mat.stat-mech] (2015)

**S. Marzen** and J. P. Crutchfield. “Informational and causal architecture of discrete-time renewal processes”, *Entropy* 17 (7), 4891-4917 (2015)

**S. Marzen** and J. P. Crutchfield. “Information anatomy of stochastic equilibria”, *Entropy* 16 (9), 4713-4748 (2014)

**S. Marzen**, H. G. Garcia, and R. P. Phillips. “Statistical Mechanics of the Monod-Wyman-Changeux (MWC) Models,” *Journal of Molecular Biology* 425(9): 1433-1460 (2013)

**S. Marzen**, D. Wu, M. Imandar, and R. P. Phillips. “Maximum Caliber model of the two-state system is equivalent to the one-dimensional Ising model,” arXiv:1008.2726 [physics.bio-ph] (2011)

BOOK CHAPTERS

C. J. Hillar and **S. E. Marzen.** “Neural network coding of natural images with applications to pure mathematics,” *Proceedings of the AMS Special Session on Algebraic and Geometric Methods*

in Discrete Mathematics, edited by: Heather Harrington, Mohamed Omar, and Matthew Wright (2017).

## CONFERENCES

### CONTRIBUTED TALKS

**S. Marzen** and J. P. Crutchfield. “Predictive feature extraction by conditionally Markovian channels in memoryful, fluctuating environments”, Information Engines Workshop, October 2018.

**S. Marzen** and J. P. Crutchfield. “Optimized bacteria are environmental prediction engines”, Society of Industrial and Applied Mathematics, August 2018.

**S. Marzen** and J. P. Crutchfield. “Optimized bacteria are environmental prediction engines”, Telluride Information Engines Workshop, July 2018.

**S. Marzen** and S. DeDeo. “Evolution of lossy compression”, Society of Industrial and Applied Mathematics, July 2016.

**S. Marzen** and S. DeDeo. “Evolution of lossy compression”, American Physical Society, March 2016.

**S. Marzen**. “New tools for dimensionality reduction in prediction”, Conference on Complex Systems Satellite Session, October 2015.

R. Mehta, **S. Marzen**, and C. Hillar. “Exploring discrete approaches to lossy compression of natural image patches”, 2015 European Signal Processing Conference.

**S. E. Marzen**, J. Zylberberg, and M. R. DeWeese. “How efficient coding of binocular disparity statistics in the primary visual cortex influences eye rotation strategy”, BMC Neurosci. 2013; 14(Suppl1): O7. (talk) Recipient of travel grant from Organization of Computational Neuroscience.

### INVITED TALKS

**S. Marzen**. “Everything’s a reservoir: Using the back of the brain to improve machine learning prediction algorithms”, FlatIron Research Institute (2021)

**S. Marzen**. “Everything’s a reservoir: Using the back of the brain to improve machine learning prediction algorithms”, Emory Physics Colloquium (2021)

**S. Marzen**. “Using lossy representations to understand the neural code?”, Organization of Computational Neuroscience Workshop on Information Theory (2020)

**S. Marzen**. “New methods for continuous-time, discrete-event prediction”, Workshop on Agency at the Interface of Quantum and Complexity Science (2020)

**S. Marzen**. “How can we predict efficiently?”, Okinawa Institute of Science and Technology Seminar Series 2020.

**S. Marzen**. “How can we predict efficiently?”, USC Physics Colloquium 2019.

**S. Marzen**. “How can we predict efficiently?”, Harvey Mudd Physics Colloquium 2019.

**S. Marzen**. “Bio-inspired problems in rate-distortion theory”, USC Information Sciences Institute 2019.

**S. Marzen.** “Bio-inspired problems in rate-distortion theory”, IEEE International Symposium on Information Theory 2019.

**S. Marzen** and A. Hsu. “Difference between memory and prediction in linear recurrent networks”, American Physical Society 2019.

**S. Marzen.** “Optimal sensors in random environments”, Redwood Neuroscience Seminar Series 2018.

**S. Marzen.** “Extracting lossy predictive features”, Info-Metrics Workshop on Causality 2018.

**S. Marzen.** “Optimal sensors in random environments”, U. Michigan 2018.

**S. Marzen.** “Predicting with limited resources”, W. M. Keck Science Department 2017.

**S. Marzen.** “Thinking in machines, not statistics”, American Physical Society 2017 [missed due to sickness] .

**S. Marzen.** “Avoiding the curse of dimensionality with maximally predictive models”, Theoretical Computer Science seminar at Indiana University, Bloomington, December 2014.

**S. Marzen** and J. P. Crutchfield. “Predictive inference in non equilibrium steady state”, Information Engines Minisymposium of SIAM Annual Meeting 2014.

**S. Marzen.** “Information-theoretic approaches to time series modeling”, Machine Learning Seminar Series at the University of Hawaii, Honolulu 2014.

#### POSTERS

**S. Marzen** et al. “Inference of functional connectivity in living neural cultures”, Organization for Computational Neuroscience (2020).

**S. Marzen** and J. P. Crutchfield. “Optimized bacteria are environmental prediction engines”, 2018 Theory in Biology Conference.

**S. Marzen** and S. DeDeo. “Weak universality in sensory tradeoffs”, 2017 International Conference on Mathematical Neuroscience.

C. Hillar and **S. Marzen.** “Revisiting perceptual distortion for natural images: mean discrete structural similarity index”, 2017 International Conference on Mathematical Neuroscience.

**S. Marzen**, M. R. DeWeese, and J. P. Crutchfield. “Predictive models of spike trains from integrate-and-fire neurons”, 2015 International Conference on Mathematical Neuroscience.

**S. Marzen**, M. R. DeWeese, and J. P. Crutchfield. “Statistical complexity of neural spike trains”, Cosyne 2014. Recipient of travel grant from Cosyne.

C. Hillar, **S. Marzen**, U. Koster, and K. Koepsell. “A Hopfield net trained on images matches retinal spike statistics and encodes images efficiently”, Cosyne 2014.

**S. Marzen**, J. Zylberberg, and M. R. DeWeese. “Modified visuomotor optimization theory to explain Listing’s Law”, J. of Vis. abstract, Vision Science Society 2013.