

# Surya Ganguli

<b>Address</b>	Department of Applied Physics, Stanford University 318 Campus Drive Stanford, CA 94305-5447 sganguli@stanford.edu <a href="http://ganguli-gang.stanford.edu/~surya.html">http://ganguli-gang.stanford.edu/~surya.html</a>
<b>Biographic Data</b>	Born in Kolkata, India. Currently US citizen.
<b>Education</b>	<b>University of California Berkeley</b> Berkeley, CA Ph.D. Theoretical Physics, October 2004. Thesis: "Geometry from Algebra: The Holographic Emergence of Spacetime in String Theory" M.A. Mathematics, June 2004. M.A. Physics, December 2000. <b>Massachusetts Institute of Technology</b> Cambridge, MA M.Eng. Electrical Engineering and Computer Science, May 1998. B.S. Physics, May 1998. B.S. Mathematics, May 1998. B.S. Electrical Engineering and Computer Science, May 1998. <b>University High School</b> Irvine, CA Graduated first in a class of 470 students at age 16, May 1993.
<b>Research Positions</b>	<b>Stanford University</b> Stanford, CA <i>Department of Applied Physics</i> Jan 12 to present <i>Department of Neurobiology, with courtesy</i> <i>Department of Electrical Engineering, with courtesy</i> Assistant Professor. <b>University of California, San Francisco</b> San Francisco, CA <i>Sloan-Swartz Center for Theoretical Neurobiology</i> Sept 04 to Dec 11 Postdoctoral fellow. <b>Lawrence Berkeley National Lab</b> Berkeley, CA <i>Theory Group</i> Sept 02 to Sept 04 Graduate student. Conducted string theory research; thesis advisor: Prof. Petr Horava. <b>MIT Department of Physics</b> Cambridge, MA <i>Center for Theoretical Physics</i> January 97 to June 98 Studied the Wigner-Weyl representation of quantum mechanics. Discovered new admissibility conditions satisfied by all Wigner distributions. Also formulated and implemented simulations of quantum dynamics directly in phase space. <b>Xerox Palo Alto Research Center</b> Palo Alto, CA <i>Dynamics of Computation Group</i> May 96 to August 96 Studied the application of quantum computation to NP-complete constraint satisfaction problems. Developed an understanding of the quantum interference process between computational paths required to successfully find solutions. <b>MIT Department of Physics</b> Cambridge, MA <i>Center for Space Research</i> January 96 to May 96 Implemented parallel algorithms for use in N-body simulations of dark matter evolution. Involved parallel programming on an IBM Sp2 Machine in a combination of High Performance Fortran and the Message Passing Interface. <b>Xerox Palo Alto Research Center</b> Palo Alto, CA <i>Information Systems and Technologies Laboratory</i> May 95 to August 95

Developed algorithms for unsupervised speaker segmentation of audio streams, using Hidden Markov Models automatically initialized via hierarchical clustering of speech.

**MIT Laboratory for Computer Science**

Cambridge, MA

*Information Mechanics Group*

*May 94 to August 94*

Developed and implemented algorithms for image processing and machine vision on a cellular automata machine.

#### **Pubs in prep.**

M. Advani and S. Ganguli, Statistical mechanics of high dimensional inference.

A. Saxe, J. McClelland, S. Ganguli, A mathematical theory of semantic cognition.

P. Gao, E. Trautmann, B. Yu, G. Santhanam, S. Ryu, K. Shenoy and S. Ganguli, A theory of neural dimensionality, dynamics and measurement.

#### **Publications**

K. Hardcastle S. Ganguli, L. Giocomo, Environmental boundaries as an error correction mechanism for grid cells, under review.

T.D. Vu, G.Q. Zhao, S. Lahiri, A. Suvrathan, H. Lee, S. Ganguli, C.J. Shatz, J.L. Raymond, Impaired learning with enhanced plasticity: a saturation hypothesis, under review.

J.Sohl-Dickstein, N. Maheswaranathan, E. Weiss, S. Ganguli, Modeling arbitrary probability distributions using non-equilibrium thermodynamics, under review.

Y. Dauphin, R. Pascanu, C. Gulcehre, K. Cho, S. Ganguli, Y. Bengio, Identifying and attacking the saddle point problem in high-dimensional non-convex optimization, Neural Information Processing Systems, 2014.

J. Sohl-Dickstein, B. Poole, and S. Ganguli, An adaptive low dimensional quasi-Newton sum of functions optimizer, International Conference on Machine Learning (ICML), 2014.

A. Saxe, J. McClelland, S. Ganguli, Exact solutions to the nonlinear dynamics of learning in deep neural networks, International Conference on Learning Representations (ICLR) 2014.

N. Giret, J. Kornfeld, S. Ganguli, R. Hahnloser. Evidence for a causal inverse model in an avian cortico-basal ganglia circuit, PNAS, 2014

B. Poole, J. Sohl-Dickstein, and S. Ganguli, Analyzing noise in auto-encoders and deep networks, Neural Information Processing Systems Workshop on Deep Learning, 2013.

S. Lahiri, and S. Ganguli, A memory frontier for complex synapses, Neural Information Processing Systems (NIPS), 2014. (\*Winner of the NIPS 2014 Outstanding paper award, given to 3 papers out of 1420 submissions.)

A. Saxe, J. McClelland, S. Ganguli, Learning hierarchical category structure in deep neural networks, In M. Knauff, M. Paulen, N. Sebanz, and I. Wachsmuth (Eds.), Proc. of the 35th annual meeting of the Cognitive Science Society, pp. 1271-1276, 2013.

J. Kao, P. Nuyujukian, S. Stavisky, S. Ryu, S. Ganguli, K.V. Shenoy, Investigating the role of firing-rate normalization and dimensionality reduction on brain-machine interface robustness. Proc. of the 35th Annual International Conference IEEE EMBS. Osaka, Japan: 293-298.

A. Hanuschkin, S. Ganguli, R.H.R. Hahnloser, A Hebbian learning rule gives rise to mirror neurons and links them to control theoretic inverse models, Frontiers in Neural Circuits (2013), 7, 00106.

M. Advani, S. Lahiri and S. Ganguli, Statistical mechanics of complex neural systems and high dimensional data, Journal of Statistical Mechanics Theory and Experiment (2013), P03014.

R. Hahnloser and S. Ganguli, Vocal learning with inverse models, book chapter in *Principles of Neural Coding*, (2013) CRC press.

S. Kim\*, S. Ganguli\* and L. Frank, Spatial Information Outflow from the Hippocampal Circuit: Distributed Spatial Coding and Phase Precession in the Subiculum, Journal of Neuroscience (2012) 32(34):11539-58. (\*equal author)

- S. Ganguli and H. Sompolinsky, Compressed sensing, sparsity and dimensionality in neuronal information processing and data analysis, *Ann. Rev. of Neuroscience*, (2012) 35:485508
- S. Ganguli and H. Sompolinsky, Short-term memory in neuronal networks through dynamical compressed sensing, *Neural Information Processing Systems* (2010).
- S. Ganguli and H. Sompolinsky, Statistical Mechanics of Compressed Sensing, *Phys. Rev. Lett.* (2010) 104:188701.
- S. Ganguli and P. Latham, Feedforward to the past: the relation between neuronal connectivity, amplification, and short-term memory, *Neuron* (2009) 61:499-501. (Preview)
- S. Ganguli, B. Huh, H. Sompolinsky, Memory Traces in Dynamical Systems, *PNAS* (2008) 105:18970-75.
- S. Ganguli, J. Bisley, J. Roitman, M. Shadlen, M. Goldberg and K. Miller, One Dimensional Dynamics of Attention and Decision Making in LIP, *Neuron* (2008) 58:15-25.
- K. Lau, S. Ganguli and C. Tang, Function Constrains Network Architecture and Dynamics: A Case Study on the Yeast Cell Cycle Network, *Phys. Rev. E* 75 (2007) 051907. ([arxiv.org/abs/q-bio/0610025](http://arxiv.org/abs/q-bio/0610025)).
- S. Ganguli, A. Ndirango and P. Horava, Boundary Scattering in 1+1 Dimensions as an Aharanov-Bohm Effect, ([arxiv.org/abs/hep-th/0501233](http://arxiv.org/abs/hep-th/0501233)).
- J. Brown, S. Ganguli, O. Ganor, C. Helfgott, E10 Orbifolds, *JHEP* 06 (2005) 057, ([arxiv.org/abs/hep-th/0409037](http://arxiv.org/abs/hep-th/0409037)).
- S. Ganguli, O. Ganor and J. Gill, Twisted Six Dimensional Gauge Theories, Matrix Models and Integrable Systems, *JHEP* 0409 (2004) 014, ([arxiv.org/abs/hep-th/0311042](http://arxiv.org/abs/hep-th/0311042)).
- E.K. Boyda, S. Ganguli, P. Horava and U. Varadarajan, Holographic Protection of Chronology in Universes of the Godel Type, *Phys. Rev. D* 67 (2003) 106003, ([hep-th/0212087](http://hep-th/0212087)).

**Selected  
Conference  
Abstracts**

- K. Hardcastle, S. Ganguli, L. Giacomo, Error accumulation and landmark-based error correction in grid cells, *Society for Neuroscience*, 2014.
- P. Gao, E. Trautmann, B. Yu, G. Santhanam, S. Ryu, K. Shenoy and S. Ganguli, A theory of neural dimensionality and measurement, *cosyne 2014*, selected for a talk.
- T.D. Nguyen-Vu, G.Q. Zhao, S. Lahiri, A. Suvrathan, H.M. Lee, S. Ganguli, C.J. Shatz, J.L. Raymond, Modeling enhanced and impaired learning with enhanced plasticity, *cosyne 2014*, selected for a talk, and chosen as the number one ranked abstract out of 550 submissions.
- M. Advani and S. Ganguli, Tractable, optimal high dimensional Bayesian inference, *cosyne 2014*.
- J. Sohl-Dickstein, N. Maheswaranathan, B. Poole, S. Ganguli, Efficient fitting of large-scale neural models, *cosyne 2014*.
- B. Poole, J. Sohl-Dickstein, S. Ganguli, Effects of noise injection in artificial neural networks, *cosyne 2014*.
- R.H.R. Hahnloser, N. Giret, J. Kornfeld, and S. Ganguli, Evidence for a causal inverse model in an avian song learning circuit, *cosyne 2013*, selected for a talk.
- A. Hanuschkin, S. Ganguli, R.H.R. Hahnloser, Closing the loop; inverse-model learning with a nonlinear avian syrinx and sparse auditory coding, *cosyne 2013*.
- K.B. Bouchard, S. Ganguli, M.S. Brainard, Hebbian mechanisms underlying the learning of Markovian sequence probabilities, *cosyne 2013*.
- A. Saxe, J. McClelland, S. Ganguli, A mathematical theory of semantic development, *cosyne 2013*.
- P. Gao, E. Trautmann, B. Yu, G. Santhanam, S. Ryu, K. Shenoy, and S. Ganguli, Dimensionality, dynamics, and correlations in the motor cortical substrate for reaching, *cosyne 2013*.

S. Lahiri and S. Ganguli, A general theory of learning and memory with complex synapses, cosyne 2013.

## Talks

Austin Conference on Learning and Memory, April. 2015.  
Simons Foundation Conference on Theory and Biology, April 2015.  
SIAM Computational Science and Engineering Conference, March 2015.  
Physics Colloquium, MIT, March 2015.  
Theoretical Neuroscience Seminar, Columbia University, Feb. 2015.  
Center for Neural Science, New York University, Feb. 2015.  
NIPS Workshop, Large scale optical physiology, Dec. 2014.  
NIPS Workshop, Deep Learning and Representation Learning, Dec. 2014.  
CIFAR, Neural Computation and Adaptive Perception Workshop, Montreal, Dec. 2014.  
Learning Lunch, Baidu, November 2014.  
Center for Physics and Biology, Rockefeller University, October 2014.  
Biophysics Theory Seminar, Princeton University, October 2014.  
Brain Criticality and Networks Workshop, Hughes Research Lab, September 2014.  
Lecturer, Methods for Computational Neuroscience, Woods Hole, MA, August 2014.  
Workshop on Deep Learning and the Brain, Cognitive Science Society, Quebec City, July 2014.  
Bernstein Lecture, Center for Computational Neuroscience, Tuebingen, July 2014.  
Group for Neural Theory, Ecole Normale Supérieure, Paris, July 2014.  
Bernstein workshop, Population Codes: From Data Analysis to Mechanisms, Munich, July 2014.  
Areadne Workshop on Neural Encoding and Decoding of Ensembles, Santorini, June 2014.  
Neural Population Dynamics Underlying Sensorimotor Integration, Janelia Farm, June 2014.  
NII-Shonan Meeting, Deep Learning: Theory, Algorithms and Applications, Tokyo, May 2014.  
Quantitative Theories of Learning, Memory and Prediction Workshop, Arlington, VA May 2014.  
Physics Colloquium, Stanford University, April 2014.  
Scalable Models for High Dimensional Neural Data, Cosyne Workshop, March 2014.  
Electrical and Computer Engineering Colloquium, Carnegie Mellon University, Feb. 2014.  
Computer Science Department, University of Montreal, Jan. 2014.  
Information Theory Forum, Stanford University, Jan 2014.  
NIPS Workshop: High dimensional statistical inference in the brain, December 2013.  
Neural Information Processing Systems (NIPS) Main Meeting, December 2013.  
Swiss Computational Neuroscience Colloquium Series, Zurich, November 2013.  
Neuroscience Center Seminar, University of Geneva, November 2013.  
Statistics Colloquium, University of Chicago, November 2013.  
Computational Neuroscience Colloquium Series, University of Waterloo, October 2013.  
Stanford Bio-X 10th Anniversary, October 2013.  
Stanford Neuroscience Retreat, October 2013.  
Lecturer, Methods for Computational Neuroscience, Woods Hole, MA, August 2013.  
Brain Initiative Advisory Committee Meeting, Boston, MA, July 2013.  
Dynamics of cortical and cortical-subcortical circuits, Janelia Farm, June 2013.  
Temporal Dynamics of Learning, Janelia Farm May 2013.  
Sensory Systems and Sensory Coding Workshop, Mathematical Biosciences Institute, May 2013.  
Networking, Communication, and DSP Seminar, Berkeley, March 2013.  
Interface of Brain and Machine Symposium, Biophysical Society Meeting, Feb 2013.  
Challenges in Mathematical Neuroscience Workshop, MBI, Ohio, Oct. 2012.  
Lecturer, Bernstein Center for Computational Neuroscience School, Goettingen, Sept. 2012.  
Colloquium, Hughes Research Lab, Malibu, CA, July 2012.  
Lecturer, Random Matrix Theory for Complex Systems Course, Okinawa, Japan, April 2012.  
Neuroscience of Music Workshop, Ascona Switzerland, March 2012.  
Neuroscience Seminar, University of Washington, March 2012.

Center for Mind Brain and Computation Seminar, Stanford University, March 2012.  
 Electrical Engineering Colloquium, Rice University, March 2012.  
 Computational Neuroscience Seminar, Janelia Farm, Feb 2012.  
 Quantitative Biology Seminar, Stanford University, Jan 2012.  
 NSF Emerging Frontiers in Research and Innovation Workshop, Dec. 2011.  
 Brains, Minds and Models Workshop, CUNY Institute for Graduate Studies, Sept. 2011.  
 Physics Colloquium, UC Merced, Sept. 2011.  
 Dept. of Electrical Engineering Seminar, Georgia Tech, Sept. 2011.  
 Physics Colloquium, Emory University, Sept. 2011.  
 International Congress on Industrial and Applied Mathematics, July 2011.  
 Telluride Neuromorphic Cognition and Engineering Workshop, July 2011.  
 Collective Behavior in Biological Systems, Aspen Center for Theoretical Physics, June 2011.  
 Bernstein Center for Computational Neuroscience Seminar, Goettingen, May 2011.  
 Department of Mathematics Seminar, Univ. of Arizona, May 2011.  
 Salk Institute for Biological Sciences, April 2011.  
 Department of Brain and Cognitive Sciences Seminar, MIT, April 2011.  
 Swissnex Public Lecture, San Francisco, March 2011.  
 Cosyne Workshop: The role of dimensionality and sparsity in neuronal processing, March 2011.  
 Computational and Systems Neuroscience Conference, Main Meeting, Feb 2011.  
 Department of Applied Physics Seminar, Stanford University, Feb. 2011.  
 Center for Brain Science Seminar, Harvard University, Feb. 2011.  
 Center for Mind, Brain and Computation Seminar, Stanford University, Feb. 2011.  
 Institute for Neuroinformatics Seminar, ETH Zurich, Jan. 2011.  
 Biological Modeling Seminar, Stanford University, November 2010.  
 Statistics Seminar, Columbia University, November 2010.  
 Kavli Institute for Theoretical Physics, UCSB, October 2010.  
 Neurotheory and Neuroengineering Seminar, Janelia Farm, May 2010.  
 Networks Seminar, Dept. of Mathematics, University of Houston, April 2010.  
 Neurobiology and Anatomy Department Seminar, UT Houston, April 2010.  
 Applied Mathematics Seminar, Harvard University, March 2010.  
 Cosyne Workshop, Persistent activity: mechanisms and functional roles, March 2010.  
 Interdisciplinary Center for Neural Computation Seminar, Hebrew University, November 2009.  
 Banbury Conference: Working Memory, Apr. 2009.  
 Cosyne Workshop: Dimensionality reduction for multi-channel neural recordings, March 2009.  
 Computational Neurobiology Lab, Salk Institute, February 2009.  
 Redwood Center for Theoretical Neuroscience Seminar, UC Berkeley, Jan. 2009.  
 Applied Mathematics Colloquium, Columbia University, Nov. 2008.  
 European Conference on Complex Systems: Working Memory in Jerusalem, Sept. 2008.  
 Banbury Conference: Theoretical/Experimental Approaches to Attention, April 2008.  
 Neural Coding, Computation and Dynamics, Hossegor, France, Sept. 2007.  
 Sloan-Swartz Conference, UCSD, July 2007.  
 Center for Neural Science Seminar, NYU, June 2007.  
 Department of Neurobiology, Yale University, June 2007.  
 Cognitive Computing Group, IBM Almaden Research Center, April 2007.  
 Gatsby Computational Neuroscience Unit, (2 seminars) April 2007.  
 Gatsby Computational Neuroscience Unit, (2 seminars) March 2007.  
 Department of Physiology, UCSF, March 2007.  
 Cosyne Workshop, Hippocampal/entorhinal plasticity, coding and computation, Feb. 2007.  
 Condensed Matter Theory Seminar, Brandeis University, February 2007.  
 Volen Center for Complex Systems, Brandeis University, January 2007.  
 Sloan-Swartz Conference, Columbia University, July 2006.

Department of Physiology, Columbia University, April 2006.  
Computational and Systems Neuroscience Conference, Main Meeting, March 2006.  
Computational Biology Seminar, UC Berkeley, October 2005.

## Awards and Activities

James S. McDonnell Foundation Scholar Award in Human Cognition, 2014-2020  
Number 1 Ranked abstract, out of 550, at Cosyne 2014  
NIPS 2014 Outstanding paper award (given to 3 papers out of 1420 submissions)  
Alfred P. Sloan Foundation Fellowship, 2013-2015  
Terman Award, 2012-2015  
Burroughs Wellcome Career Award at the Scientific Interface, 2009-2014  
Sloan-Swartz Fellowship, 2004-2009  
Berkeley Outstanding Graduate Instructor  
Tau Beta Pi  
Phi Beta Kappa  
MIT Varsity Tennis  
MIT Treasurer of the South Asian Association of Students  
Member of MIT and Berkeley Bhangra Dance Teams  
MIT EECS Tutor  
Cambridge Elementary School Volunteer  
National Merit Scholar  
National Council of Teachers of English Award in Writing

## Teaching

Stanford Department of Applied Physics.  
AP293 *Theoretical Neuroscience*, Spring 2014, (51 students)  
AP205 *Introduction to Biophysics*, Winter 2014, (19 students)  
AP293 *Theoretical Neuroscience*, Spring 2013, (24 students)  
AP205 *Introduction to Biophysics*, Winter 2013, (10 students)  
AP293 *Theoretical Neuroscience*, Spring 2012, (26 students)  
UCSF Neuroscience Graduate Program, 2010.  
Taught a section *Information Theory in Neuroscience* in Loren Frank's *Neural and Behavioral Data Analysis* course.  
Columbia Center for Theoretical Neuroscience, 2008.  
Co-taught *Advanced Theoretical Neuroscience* with Larry Abbott, Stefano Fusi, and Ken Miller.  
Berkeley Department of Physics, 1998-2002.  
Graduate student instructor for the following courses:  
*Introduction to Electricity and Magnetism* (for premedical students).  
*Analytical Mechanics*.  
*Electromagnetism and Optics*.  
*Introduction to Statistical and Thermal Physics*.  
*Special Relativity and General Relativity*.  
*Quantum Mechanics*.  
MIT Department of Electrical Engineering and Computer Science, 1997-1998.  
Teaching assistant for *Probabilistic systems analysis*.

## Invited Academic Visits

Kavli Institute for Theoretical Physics, UCSB, Sept.-Oct. 2010 (1 month).  
Interdisciplinary Center for Neural Computation, Hebrew University, 2007-2009 (4 months).  
Movement Control Laboratory (Emo Todorov), UCSD, Feb. 2009 (1 month).  
Center for Brain Science, Harvard University, 2006-2009 (6 months).  
Center for Theoretical Neuroscience, Columbia University, 2007-2008 (1 year).  
Gatsby Computational Neuroscience Unit, Apr. 2007 (1 month).  
Algebraic Geometry in Biology Workshop, IMA, University of Minnesota, Mar. 2007 (1 week).  
Mathematical Neuroscience Lab, RIKEN Brain Science Institute, Jun.-Aug. 2005 (2 months).

## Invited Summer Schools

Boulder School for Condensed Matter: Biophysics (2007).  
UCSD CTBP: Quantitative Approaches to Gene Regulatory Systems (2006).

Weizmann Institute: Physics of Nonequilibrium Complex Systems (2006).  
BioMaps: Molecular Mechanisms and Models of Bacterial Signal Transduction (2005).  
RIKEN Brain Science Institute: Neurobiology of Mental Disorders and the Mind (2005).  
Okinawa School on Bayesian Methods in Computational Neuroscience (2004).  
Woodshole MBL: Methods in Computational Neuroscience (2004).  
Santa Fe Institute Complex Systems Summer School (2004).  
Boulder Theoretical Advanced Study Institute on Recent Trends in String Theory (2003).  
Cargese Institute on Progress in String, Field, and Particle Theory, Corsica, France (2002).  
Princeton School on Quantum Field Theory, Supersymmetry and Enumerative Geometry (2001).  
Harvard Summer School on Mirror Symmetry (2000).