

CURRICULUM VITAE

Paul So

Associate Professor
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Education

Doctor of Philosophy in Physics, University of Maryland,
College Park, Maryland, May of 1995 - Advisor: Edward Ott, Ph.D.
Bachelor of Science in Physics and Mathematics, Harvey Mudd College,
Claremont, California, May of 1988.
Bachelor of Arts in Studio Arts, Scripps College,
Claremont, California, May of 1988.

Dissertation

P. So, "Observing and Controlling Chaotic Systems and Wave Chaos Statistics,"
Ph.D. dissertation, University of Maryland, May 1995.

Research Experience

Associate Professor, Department of Physics and Astronomy and the Krasnow Institute for
Advanced Study, George Mason University, Fairfax, Virginia, 2003-present.

Assistant Professor, Department of Physics and Astronomy and the Krasnow Institute for
Advanced Study, George Mason University, Fairfax, Virginia, 1998-2003.

Assistant Professor of Pediatrics, George Washington University School of Medicine and
the Children's Research Institute of the Children's National Medical Center,
Washington, D.C., 1998.

Research Assistant Professor in Pediatrics, Children's Research Institute of the Children's
National Medical Center and the George Washington University School of
Medicine, Washington D.C., 1997-1998.

Postdoctoral Research Assistant, Center for Neuroscience, Children's Research Institute
of the Children's National Medical Center, Washington D.C., 1995 - 1997.

Graduate Research Assistant, Institute for Plasma Research, University of Maryland, College Park, Maryland, 1991 - 1995.

Graduate Research Assistant, NASA Goddard Space Flight Center, Greenbelt, Maryland, Summer 1989.

Teaching Experience

Associate Professor, Department of Physics and Astronomy and the Krasnow Institute for Advanced Study, George Mason University, Fairfax, Virginia, 2003-present.

Assistant Professor, Department of Physics and Astronomy, George Mason University, Fairfax, Virginia, 1998-2003.

Graduate Teaching Assistant, Department of Physics, University of Maryland, College Park, Maryland, 1988 - 1991.

Grants Received

“Dynamics and Control of Neuronal Pattern Formation”, (Co-Principal Investigator) NIH (RO1): - Amount of Award: \$1,900,000 (Oct. 1, 2003 – Sept. 30, 2008)

“A Dynamical Framework for Transient Neuronal Patterns”, (Co-Principal Investigator) NIH (RO3): - Amount of Award: \$50,000 (Dec. 1, 2003 – Jan. 30, 2005)

“Electric Field as a Novel Neuronal Interface”, (Co-Principal Investigator) NIH (RO1): - Amount of Award: \$1,400,000 (June 1, 2003 – May 31, 2007)

“A New Thermodynamics Formalism for Neuronal Ensemble – Supplement to an ongoing NSF grant” (Principal Investigator) National Science Foundation: Computational Neuroscience Program (IBN-9727739) – Amount of Additional Award: \$39,980 (Sept. 1, 1998 – June 30, 2002)

“A New Thermodynamics Formalism for Neuronal Ensemble” (Principal Investigator) National Science Foundation: Computational Neuroscience Program (IBN-9727739) – Amount of Award: \$219,451 (Sept. 1, 1998 – June 30, 2002)

“Electric Field Suppression of Epileptic Seizures” (Co-Principal Investigator) Whitaker Foundation (100159) – Amount of Award: \$210,000 (May 1, 2000 – April 30, 2003)

“Nonlinear Dynamics of Neuronal Ensembles” (Co-Principal Investigator) National Institute of Health (2RO1MH5006-06A1) – Amount of Award: \$849,099 (June 25, 1998 – June 24, 2003)

“Establishing the Sensitivity of Neurons and Networks to Electric Fields through Nonlinear Dynamical Measures” (Co-Principal Investigator) US Dept. of Energy (85X-SX516V) – Amount of Award: \$139,901 (May 1997 – Feb. 1999)

Fellowships

Institute for Plasma Research/Naval Research Laboratory Graduate Fellowship, 1994 - 1995.

Professional Memberships

Member of American Physical Society, 1992-present.

Member of Society for Industrial and Applied Mathematics, 1995-present.

Member of The Mathematical Association of America, 2000-present.

Member of Society for Neuroscience, 2005-present.

Professional Activities

Organizer for Nonlinear Science Group Seminar series, George Mason University, 1998-present.

Deputy Director for the Physical Sciences PhD program, George Mason University, fall 2006-present.

Organizer for the Department of Physics and Astronomy Seminar series, George Mason University, fall 2001-spring 2005.

Organizer for the “Minisymposium on Problems in Nonlinear Synchrony,” The Sixth Conference on Applications of Dynamical Systems, Snowbird, Utah, May 2001.

Organizer for the “Minisymposium on Beyond Generalized Synchrony,” The 2000 Pacific Rim Dynamical Systems Conference, Maui, Hawaii, August 2000.

Organizer for the “Minisymposium on Topological Entropy and Average Expansion Rates, Communication, Synchrony, and Dimension,” Fifth SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah, May 1999.

Reviewer for Physical Review Letters, Physical Review E, Physica D, Chaos, IEEE Transaction on Biomedical Engineering, Neural Computation, the National Science Foundation, and the U.S. Civilian Research and Development Foundation (CRDF).

Peer-Reviewed Publications

P. So, Unstable Periodic Orbits. *Scholarpedia* (http://www.scholarpedia.org/article/Unstable_Periodic_Orbits), 8745 (2007).

- E. Sander, E. Barreto, S. J. Schiff, and P. So, Dynamics of Noninvertibility in Delay Equations, *Discrete and Continuous Dynamical Systems, Supplemental Volume*, 768-777 (2005).
- E. Ott, P. So, E. Barreto, and T. Antonsen, "The Onset of Synchronism in Globally Coupled Ensembles of Chaotic and Periodic Dynamical Units" in *Chaotic Dynamics and Transport in Classical and Quantum Systems*, Proceedings of the NATO Advanced Study Institute on International Summer School on Chaotic Dynamics and Transport in Classical and Quantum Systems, Cargèse, Corsica, 18 - 30 August 2003, Series: NATO Science Series II: Mathematics, Physics and Chemistry, Vol. 182, Collet, P.; Courbage, M.; Métens, S.; Neishtadt, A.; Zaslavsky, G. (Eds.), Springer, (2005).
- E.-H. Park, E. Barreto, B. J. Gluckman, S. J. Schiff, and P. So, A Model of the Effects of Applied Electric Field on Neuronal Synchronization, *Journal of Computational Neuroscience*, **19**, 53-70 (2005).
- E.-H. Park, P. So, E. Barreto, B. J. Gluckman, and S. J. Schiff, Electric Field Modulation of Synchronization in Neuronal Networks, *Neurocomputing*, **52-54**, 169-175 (2003).
- E. Ott, P. So, E. Barreto, T. Antonsen, Synchrony in Globally Coupled Chaotic, Periodic, and Mixed Ensembles of Dynamical Units, in *Synchronization: Theory and Application*, eds. A. Pikovsky and Y. Maistrenko, (Kluwer Academic Publications, Netherlands, 2003).
- E. Barreto, K. Josic, C. J. Morales, E. Sander, and P. So, The Geometry of Chaos Synchronization, *Chaos*, **13** 151 (2003).
- E. Ott, P. So, E. Barreto, T. Antonsen, The Onset of Synchronization in Systems of Globally Coupled Chaotic and Periodic Oscillators, *Physica D*, **173** 29 (2002).
- P. So, E. Barreto, K. Josic, E. Sander, and S. J. Schiff, Limits to the Experimental Detection of Nonlinear Synchrony, *Phys. Rev. E*, **65** 046225 (2002).
- J. Chubb, E. Barreto, P. So, and B. J. Gluckman, The Breakdown of Synchronization in Systems of Non-identical Chaotic Oscillators: Theory and Experiment, *Int. J. of Bifurcation and Chaos*, **11** 2705 (2001).
- E. Barreto, and P. So, The Breakdown of Synchronization and Shadowing in Coupled Chaotic Systems: Analysis via the Subsystem Decomposition, *Space-Time Chaos: Characterization, Control, and Synchronization*, S. Boccaletti et. al. eds, (World Scientific, Singapore, 2001).

- J. T. Francis, P. So, B. J. Gluckman, and S. J. Schiff, "Differentiability Implies Continuity in Neuronal Dynamics," *Physica D*, **148** 175 (2000).
- E. Barreto, and P. So, "Mechanisms for the Development of Unstable Dimension Variability and the Breakdown of Shadowing in Coupled Chaotic Systems," *Phys. Rev. Lett.*, **85** 2490 (2000).
- E. Barreto, P. So, Bruce J. Gluckman, Steven J. Schiff, "From Generalized Synchrony to Topological Decoherence: Emergent Sets in Coupled Chaotic Systems," *Phys. Rev. Lett.*, **84** 1689 (2000).
- P. So, E. Barreto, and B. Hunt, "Box-Counting Dimension without Boxes: Computing D_0 from Average Expansion Rates," *Physical Review E*, **59** 378 (1999).
- Yang Qian, "Periodic Orbits: A New Language for Neuronal Dynamics," *Advances in Mechanics*, **29** 121 (1999) (in Chinese), translated from: P. So, J. T. Francis, T. I. Netoff, B. J. Bluckman, and S. J. Schiff, "Periodic Orbits: A New Language for Neuronal Dynamics," *Biophys. J.*, **74** 2776 (1998).
- B. J. Gluckman, P. So, T. I. Netoff, M. L. Spano, and S. J. Schiff, "Stochastic Resonance in Mammalian Neuronal Networks," *Chaos*, **8** 588 (1998).
- P. So, J. T. Francis, T. I. Netoff, B. J. Bluckman, and S. J. Schiff, "Periodic Orbits: A New Language for Neuronal Dynamics," *Biophys. J.*, **74** 2776 (1998).
- P. So, E. Ott, T. Sauer, B. J. Gluckman, C. Grebogi, and S. J. Schiff, "Extracting Unstable Periodic Orbits from Chaotic Time Series Data," *Phys. Rev. E*, **55** 5398 (1997).
- S. J. Schiff, P. So, T. Chang, R. E. Burke, and T. Sauer, "Detecting Dynamical Interdependence and Generalized Synchrony through Mutual Prediction in a Neural Ensemble," *Phys. Rev. E*, **54** 6708 (1996).
- P. So, E. Ott, S. J. Schiff, D. T. Kaplan, T. Sauer, and C. Grebogi, "Detecting Unstable Periodic Orbits in Chaotic Experimental Data," *Phys. Rev. Lett.*, **76** 4705 (1996).
- R. N. Oerter, E. Ott, T. M. Antonsen, Jr., and P. So, "Spectral Statistics for Quantum Chaos with Ray Splitting," *Phys. Lett. A*, **216** 59 (1996).
- P. So and E. Ott, "Controlling Chaos Using Time Delay Coordinates via Periodic Orbits," *Phys. Rev. E*, **51** 2955 (1995).
- P. So, S. M. Anlage, E. Ott, and R. N. Oerter, "Wave Chaos Experiments with and without Time Reversal Symmetry: GUE and GOE Statistics," *Phys. Rev. Lett.*, **74** 2662 (1995).

P. So, E. Ott, and W.P. Dayawansa, “Observing Chaos: Deducing and Tracking the State of a Chaotic System from Limited Observation,” *Phys. Rev. E*, **49** 2650 (1994).

P. So, S. M. Anlage, and E. Ott, “Experiments on Quantum Chaos with and without Time Reversal Symmetry,” Proceedings to the Second Experimental Chaos Conference, Arlington, Virginia, November, 1993.

P. So, E. Ott, and W.P. Dayawansa, “Observing Chaos: Deducing and Tracking the State of a Chaotic System from Limited Observation,” *Phys. Lett. A*, **176** 421 (1993). This also appears in “Coping with Chaos”, editors, Edward Ott, Time Sauer, and James A. Yorke, (John Wiley and Sons, New York, 1994).

Articles Written on My Work

J. Glanz, “Maturing the Nonlinear Brain,” *Science* **277**, 1758 (1997).

Invited Presentations

“Model of Electric Field Modulation on Neuronal Synchrony and Wave Propagation,” School for Computational Sciences Colloquium, George Mason University, September 2005.

“Model of Electric Field Modulation on Neuronal Synchrony and Wave Propagation,” *International Seminar and Workshop: Nonlinear Dynamics in Biophysics*, Max-Planck-Institut für Physik Komplexer Systeme, Dresden, Germany, June-July 2005.

“Controlling Neuronal Synchronization and Waves with Electrical Fields,” Minisymposium on Pattern Formation and Wave Dynamics in the Brain, *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2005.

“Synchrony in Nature: From Clocks to Neurons,” Learning in Retirement, Osher Lifelong Learning Institute, George Mason University, Fairfax VA, October 2004.

“Synchrony in Nature: From Clocks to Neurons,” The Krasnow Institute Seminars, The Krasnow Institute for Advanced Study, George Mason University, Fairfax VA, May 2004.

“Synchrony in Nature: From Clocks to Neurons,” The Philosophical Society of Washington, John Wesley Powell Auditorium: 2169th Meeting, Cosmos Club, Washington DC, December 2003.

“The Onset of Synchronism in Globally Coupled Ensembles of Chaotic and Periodic Oscillators,” Minisymposium on Stability and Pattern Formation in Dynamics on

- Networks, *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2003.
- “Synchrony in Model Neurons in an Electric Field,” Minisymposium on Synchrony in Neuroscience – Part I, *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2003.
- “The Onset of Synchrony in Globally Coupled Chaotic Systems,” *Physics and Astronomy Colloquium (Joint with Nonlinear Science Group Seminar)*, George Mason University, Fairfax, November 2001.
- “Limits to Detecting Nonlinear Synchrony,” *Gordon Research Conference on Nonlinear Sciences*, Mt. Holyoke, Massachusetts, June 2001.
- “Limits to Detecting Nonlinear Synchrony,” Minisymposium on Problems in Nonlinear Synchrony, *The Sixth Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2001.
- “What can you expect from nontrivial collective behavior in coupled systems?” School for Computational Sciences Colloquium, George Mason University, April 2001.
- “Limits to the Detection of Nonlinear Synchrony,” *The BioDynamics Seminar*, Center for Biodynamics, Boston University, Boston, Massachusetts, December 2000.
- “Limits to the Detection of Nonlinear Synchrony,” Minisymposium on Beyond Generalized Synchrony, *The 2000 SIAM Pacific Rim Dynamical Systems Conference*, Maui, Hawaii, August 2000.
- “Box-Counting Dimension without Boxes: Computing D_0 from Average Expansion Rates,” Chaos and Complexity Center Lectures, Mathematics Department, US Naval Academy, Annapolis, September 1999.
- “Nonlinear Dynamics in Neuronal Ensembles,” *Dynamics Days 1999 Como Italy*, Villa Olmo, Como, Italy, June 1999.
- “Box-Counting Dimension without Boxes: Computing D_0 from Average Expansion Rates,” Minisymposium on Topological Entropy Average Expansion Rates: Communication, Synchrony, and Dimension, *Fifth SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 1999.
- “Box-Counting Dimension without Boxes: Computing D_0 from Average Expansion Rates,” Applied Dynamics Seminar, University of Maryland at College Park, April 1999.

“Metamorphoses of Periodic Orbits in Desynchronizing Chaotic Systems,” Institute for Computational Sciences and Informatics Colloquium, George Mason University, April 1999.

“Periodic Orbits Metamorphosis for Coupled Chaotic Systems,” Mathematical Tools for Neural System Analysis, Defense Advanced Research Projects Agency, Arlington, Virginia, July 1998.

“From Generalized Synchrony to Topological Decoherence,” *International Conference on Periodic Orbits Theory in Biology*, Krasnow Institute for Advanced Study, George Mason University, Fairfax, Virginia, July 1998.

“Periodic Orbits: A New Language for Neuronal Dynamics,” George Mason University, Fairfax, Virginia, November 1997.

“Detecting Unstable Periodic Orbits in Chaotic Experimental Data,” *International Workshop on Nonlinear Techniques in Physiological Time Series Analysis*, Max Planck Institute for Physics of Complex Systems, Dresden, Germany, October 1995.

Contributed Presentations

“The Breakdown of Synchronization and Shadowing in Coupled Chaotic Systems: Analysis via the Subsystem Decomposition,” *International School on Space Time Chaos: Characterization Control and Synchronization*, Pamplona, Spain, June 2000.

“Mechanisms for the Development of Unstable Dimension Variability and the Breakdown of Shadowing in Coupled Chaotic Systems,” *Workshop on: Complex Synchronization in Neuroscience*, Krasnow Institute for Advanced Study, George Mason University, Fairfax, Virginia, May 2000.

“Synchrony, Emergent Sets, and Topological Decoherence,” *Dynamics Days Asia Pacific*, Hong Kong, China, July 1999.

“Average Expansion Rates and Dimension of Strange Nonchaotic Attractors,” *Fifth SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 1999.

“Box-Counting Dimension without Boxes: Computing D_0 from Average Expansion Rates,” *Centennial Meeting of the American Physical Society*, Atlanta, Georgia, March 1999.

“Characterization of Complex Neuronal Dynamics by Unstable Periodic Orbits,” *Gordon Research Conference on Bioelectrochemistry*, New England College, NH, July 1998.

- “Characterization of Complex Neuronal Dynamics by Unstable Periodic Orbits,”
American Physical Society Annual Meeting, Los Angeles, CA, March 1998.
- “Periodic Orbits Analysis in Mammalian Neuronal Ensemble,” *Sixth Annual Computational Neuroscience Meeting*, Big Sky, MT, July 1997.
- “Detecting Unstable Periodic Orbits in Chaotic Experimental Data,” *The Fourth SIAM Conference on Applications of Dynamical Systems*, Snow Bird, UT, May 1997.
- “Detecting Unstable Periodic Orbits in Chaotic Experimental Data,” *American Physical Society Annual Meeting*, St. Louis, MI, March 1996.
- “Detecting Dynamical Interdependence and Generalized Synchrony through Mutual Prediction in a Neural Ensemble,” *American Physical Society Annual Meeting*, St. Louis, MI, March 1996.
- “Controlling Chaos using Time Delay Coordinates via Stabilization of Periodic Orbits,”
The Third SIAM Conference on Applications of Dynamical Systems, Snow Bird, UT, May 1995.
- “Experiments on Quantum Chaos with and without Time Reversal Symmetry,” *4th Drexel Symposium on Quantum Nonintegrability*, Drexel University, Philadelphia, PA, September 1994.
- “Experiments on Quantum Chaos with and without Time Reversal Symmetry,” *The 2nd Experimental Chaos Conference*, Arlington, VA, October 1993.

Postdoctoral Research Directed

Eun-Hyoung Park, PhD – 2001-2003
Ernest Barreto, PhD – 1998-2000

Graduate/Undergraduate Research Directed

Clayton Fan, PhD candidate, George Mason University – 2005 - present
Bernie Cotton, MS candidate, George Mason University – 2005 - present
Karen Graver, PhD candidate, George Mason University – 2005 - present
Mark Hannum, PhD candidate, George Mason University – 2004 – present
Mark Allan Chevillet, PhD candidate, Georgetown University - 2005
Karen Graver, MS Thesis, George Mason University – 2004 -2005
Matthew Picket, MS Thesis, George Mason University – 2003 - 2004
Jonathan Steidel, PhD candidate, George Mason University – 2002 - 2003
Steve Richardson, Senior Thesis, George Mason University – 2001 - 2002
Jennifer C. Chubb, PhD candidate, George Mason University – 1999 – 2001

Arts Exhibitions: The following is a list of both solo and group exhibitions of my paintings in various galleries.

One Person Exhibitions

``Converging Observer," The Gallery, Greenbelt, Maryland, October 1994.

``ONE," Publick Playhouse Inner Gallery, Riverdale, Maryland, November 1992.

Group Exhibitions

Eleventh Annual ``Faber Birren Color Award Show," Stamford Arts Association, Stamford, Connecticut, September 1991.

``Color and Motion," Ariel Gallery, SOHO, New York, April 1991.

Group Exhibition, Artists Underground Studio and Gallery, Alexandria, Virginia, November 1990.

Scripps Senior Art Exhibit, Montgomery Gallery, Pomona College, Claremont, California, May 1988.

Group Show in campus center's gallery, Harvey Mudd College, Claremont, California, March 1988.

Winner of yearly competition/exhibition, Lang gallery, Scripps College, Claremont, California, May 1987.