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DANIEL J. GAUTHIER, PROFESSOR OF PHYSICS AND BIOMEDICAL ENGINEERING

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Teaching (Spring 2010):

PHYSICS 271.01, *QUANTUM OPTICS*
 SEE INSTRU, TuTh 02:50 PM-04:05 PM

Education:

- Optics, University of Rochester, 1989
- Optics, University of Rochester, 1983
- Optics, University of Rochester, 1982

Specialties:

Heart, Electrophysiology

Research Interests: *Quantum Electronics, Biophysics, and Nonlinear Dynamics*

Prof. Gauthier is interested in a broad range of topics in the fields of nonlinear and quantum optics, biophysics, and nonlinear dynamical systems.

In the area of optical physics, his group is studying the fundamental characteristics of highly nonlinear light-matter interactions and is using this understanding to develop practical devices. Recently, they have been interested in tailoring the group velocity of laser-driven materials to achieve group velocities that are much greater than or much less than the speed of light in vacuum (so-called fast and slow light). They are measuring the speed at which information travels through fast- and slow-light media to test our understanding of the special theory of relativity, and they are transitioning the slow-light technology to telecommunications applications such as all-optical signal regeneration and processing. Another recent interest is the development of the world's most sensitive all-optical switch. Currently, they have observed switching with an energy density as low as a few hundred yoctoJoules per atomic cross-section, indicating that the switch should be able to operate at the single-photon level.

In the area of biophysics, his group is investigating the electrical activity of the heart from a nonlinear dynamics perspective. It is a multi-disciplinary effort consisting of faculty and students from the departments of Biomedical Engineering, Mathematics, and Physics. They are developing techniques for controlling cardiac dynamics using real-time closed-loop feedback, with the long-term goal of realizing an implantable ultra-low-energy cardiac defibrillator for people at high risk of sudden cardiac death. They are also developing new experimental methods for characterizing the nonlinear response of cardiac tissue and using the resulting data to guide the development of mathematical models for describing the generation and propagation of electrical waves in the heart.

In the area of nonlinear dynamics, his group is interested in the control and synchronization of chaotic devices, especially optical and radio-frequency electronic systems. They are developing new methods for private communication of information using chaotic carriers, using chaotic elements for distance sensing (e.g., low-probability-of-detection radar), using networks of chaotic elements for remote sensing, and using chaotic elements for generating truly random numbers at high data rates.

Awards, Honors, and Distinctions

Fellow, Optical Society of America, October, 2006
Young Investigator, National Science Foundation, July 1993 - June 1998
Young Investigator, U.S. Army Research Office, July 1992 - June 1995
Fellow of the American Physical Society, Division of Atomic, Molecular, and Optical Physics, November, 2002
Anne T. and Robert M. Bass Associate Professor of Physics, Duke University, 2002-2007
Barbara and Randal Smith and Duke University Faculty Enrichment Award, Duke University, July 2000 - June 2001
Honorary Faculty Member, Golden Key National Honor Society, April, 1997

Current Ph.D. Students (Former Students)

- Zheng Gao
- Seth D. Cohen
- Yunhui Zhu
- Joel A Greenberg
- Carolyn M. Berger
- Andrew M. Dawes
- Hana Dobrovolny

Postdocs Mentored

- Rui Zhang (February, 2008 - present)
- Hugo L Cavalcante (February, 2008 - present)
- Eduardo Granado-Cabrera (October 1, 2007 - September 30, 2008)
- Xiaopeng Zhang (May 01, 2005 - June 30, 2007)
- Zhaoming Zhu (September 01, 2004 - June 30, 2008)
- Lucas Illing (February 01, 2003 - June 30, 2007)
- Elena Tolkacheva (May 1, 2001 - June 30, 2004)
- John C. Swartz (January, 1999 - September, 1999)
- Olivier Pfister (1997 - 1999)
- Sonya Bahar (1997 - 1999)
- Jeff R. Gardner (1995 - 1997)

Recent Publications (More Publications)

D.J. Gauthier, *Superluminal communication in quantum mechanics*, in an invited article in Compendium of Quantum Physics: Concepts, Experiments, History and Philosophy, edited by B. Falkenburg, D. Greenberger, K. Hentschel, and F. Weinert (Accepted, 2009), Springer .
R.W. Boyd, D.J. Gauthier, and P. Narum, *Causality in superluminal pulse propagation*, in an invited chapter in Time in Quantum Mechanics II, edited by J. G. Muga (Accepted, 2009), Springer .
Recent advancements in SBS Slow Light, *E. Cabrera-Granado and D.J. Gauthier*, an invited article in Opt. Pura Apl., vol. 41 (December, 2008), pp. 313 [pdf] .
J.A. Greenberg and D.J. Gauthier, *Transient dynamics and momentum redistribution in cold atoms via recoil-induced resonances*, Phys. Rev. A (Submitted, December, 2008) .
X. Zhao, D.G. Schaeffer, C.M. Berger, W. Krassowska, and D.J. Gauthier, *Cardiac alternans arising from an unfolded border-collision bifurcation*, J. Comput. Nonlinear Dynam., vol. 3 (October, 2008), pp. 041004 [pdf] .

Selected Invited Lectures

Slow and stopped light in optical waveguides, August 29, 2008, DTU Fotonik Seminar, Danmarks Tekniske Universitet, Bygning, Denmark
Slow and stopped light in optical waveguides, August 27, 2008, Keynote Lecture, PHOTON 08, Edinburg, UK
Chaos in simple high-speed logic-based devices, July 21, 2008, 25 Years of Nonlinear Dynamics at ONR (a celebration of Mike Shlesinger's 60th Birthday), Amelia Island, FL
Three lectures on the Physics and Application of Slow Light, June 25-27, 2008, Masters in Photonics Program (Photonics BCN), Barcelona, Spain
Boolean delay devices, April 17, 2008, U. Maryland, MURI Seminar, U. Maryland, College Park, MD
Evidence for an unfolded border-collision bifurcation in paced cardiac muscle, April 17, 2008, Nonlinear Dynamics Seminar, U. Maryland, College Park, MD
Observation of Stopped Light in an Optical Fiber via Stimulated Brillouin Scattering, January 07, 2008, 38th Winter Colloquium on the Physics of Quantum Electronics, PQE-2008, Snowbird, UT
Slow Light, Fast Light, Backward Light: What does it all mean?, November 30, 2007, Physics

Department Colloquium, Bates College, Lewiston, ME

Progress on stopped light and large-delay slow light in optical fibers, July 11, 2007, OSA , Topical meeting on Slow and Fast Light, Salt Lake City, UT

Tutorial: Slow-light in room-temperature optical waveguides, June 18, 2007, International Quantum Electronics Conference (IQEC) 2007, Munich, Germany

Broadband chaos in time-delay photonic and electroic devices: Potential implications for sensor networks, May 23, 2007, Nonlinear Dynamics Seminar, University of Maryland, College Park, MD

Ultra-low-light-level all-optical switching, September 15, 2006, Physics Department Colloquium, Ohio University, Athens, OH

Discovery of a new type of bifurcation in paced cardiac muscle, July 14, 2006, Third Workshop Promotionskolleg, Helmholtz Center for Brain and Mind Dynamics, Liebenwalde, Germany

Using dissipative spatial structures to achieve ultra-low-light-level optical switching, July 26, 2005, XXV Dynamics Days Europe, Berlin, Germany

Characterizing and controlling cardiac dynamics, June 29, 2005, International Seminar and Workshop on Nonlinear Dynamics in Biophysics, Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

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