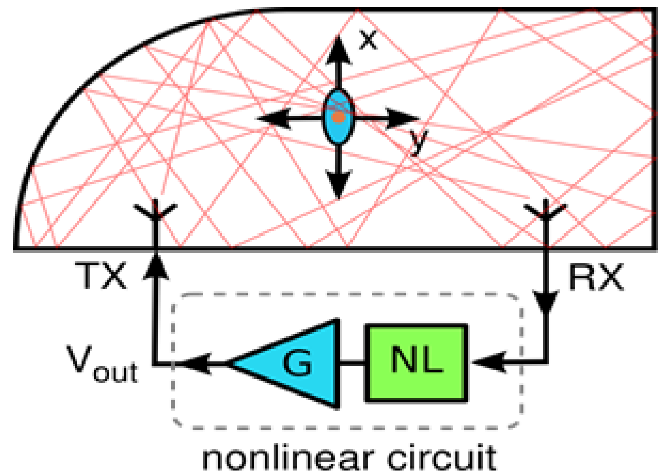
The Institute of OPTICS

Colloquium

UNIVERSITY OF ROCHESTER

Sub-wavelength position sensing using chaos



Daniel J. Gauthier

Robert C. Richardson Professor of Physics
Duke University
BS and PhD in Optics, Rochester
Postdoc, Oregon

I will describe our recent work that demonstrates full two-dimensional position sensing with a resolution of ~λ/300. Possible applications include through-wall position sensing and tracking of sub-wavelength objects.

3:00 pm Monday, April 16, 2012
Sloan Auditorium, Goergen 101

HAJIM
SCHOOL OF ENGINEERING
& APPLIED SCIENCES

Sub-wavelength position sensing using chaos

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Abstract: Diffraction, a property of electromagnetic waves, blurs spatial information less than the wavelength of an illuminating source and hence limits the resolution of images. Over the past several years, research teams have discovered different approaches for beating the diffraction limit, leading to a revolution in biological imaging where sub-cellular structures tend to be smaller than the typical illumination wavelength. Each super-resolution method has advantages and disadvantages so it is important to continue to develop new imaging modalities and transition them to practical application in biological imaging. Some of the existing methods use fluorescent molecules that serve as sub-wavelength point markers, where imaging is enabled by sensing the position of the markers. Here, we describe a new position-sensing modality that relies on the inherent sensitivity of chaos. We illuminate a sub-wavelength object with a complex structured radio-frequency field generated using an inexpensive nonlinear feedback loop. Analyzing the frequency content of the waveform in the feedback loop allows us to extract position information of the object along either of two orthogonal directions with a resolution of ~λ/10,000. We generalize this method to demonstrate full two-dimensional position sensing with a resolution of ~λ/300. Possible applications include through-wall position sensing and tracking of sub-wavelength objects. We also discuss possible extensions of this work to three dimensions and to optical microscopy.

Biography: Daniel J. Gauthier received the B.S., M.S., and Ph.D. degrees in Optics from the University of Rochester, Rochester, NY, in 1982, 1983, and 1989, respectively. His Ph.D. research on Instabilities and chaos of laser beams propagating through nonlinear optical media was supervised by Prof. R. W. Boyd and supported in part through a University Research Initiative Fellowship. From 1989 to 1991, he developed the first continuous-wave two-photon optical laser as a Post-Doctoral Research Associate under the mentorship of Prof. T. W. Mossberg at the University of Oregon. In 1991, he joined the faculty of Duke University, Durham, NC, as an Assistant Professor of Physics and was named a Young Investigator of the U.S. Army Research Office in 1992 and the National Science Foundation in 1993. He is currently the Robert C. Richardson Professor of Physics. His research interests include: nonlinear quantum optics, dynamics of complex networks, quantum key distribution, slow light, and nonlinear metamaterials. Prof. Gauthier is a Fellow of the Optical Society of America and the American Physical Society.