SYMPOSIUM ON UNDERGRADUATE RESEARCH

Division of Laser Science of A.P.S - LS XXVII - 17 October 2011 - San Jose , CA

PARTICIPANTS' LUNCHEON – Glen Ellen Room - 12:00

The participants' lunch will bring together the Symposium students and Plenary Speakers

Prof. Sir John Pendry (Imperial College) and Prof. Ferenc Krausz (MPQ)

Lunches will be provided for participants and invited guests only.

POSTER SESSION – South Tower Foyer - 12:15

Session LMA: 12:15 - 2:25 PM, South Tower Foyer - Jenny Magnes, Vassar College, Presider

LMA1 - **Real-time Non-invasive Optical Method for Sensing Degradation of Engine Oil Quality in Automobiles**, *Miao Dong, Bradley Worth II, Sarabjot Makkar, Kashika Goyal, Lalit Bali, and Samir Bali; Miami University, Oxford, OH 45056.* We demonstrate real-time sensitive detection of engine oil degradation with use. Our home-built optical sensor relies on a new model that we recently developed for total internal reflection from turbid media. By contrast, the "oil quality indicator" in cars is a "guess" based on mileage, and involves no actual sensing. Supported by Petroleum Research Fund and Miami University.

LMA2 - **Polarization Patterns of High-order Vector Beams,** *Shreeya Khadka and Enrique Galvez; Physics, Colgate University, Hamilton, NY 13346*. We used a Mach-Zehnder interferometer and forked diffraction gratings to produce a superposition of Laguerre-Gauss beams with orthogonal polarizations. The output is a high-order "Poincaré" vector beam that exhibits all polarization states in the same beam profile. Supported by NSF.

LMA3 - **Study of Relaxation Oscillations and Spiking Behavior in an Erbium Doped Fiber Ring Laser,** *Joe Cocchi[1], Fuad Rawwagah[2], and Surendra Singh[2]; 1) College of Optical Sciences, University of Arizona, Tucson, AZ 85721, 2) Physics, University of Arkansas, Fayetteville, AR 72701*. Relaxation oscillations and spiking behavior in an erbium doped fiber ring laser were used to determine upper level decay time and internal cavity losses as well as the distribution of onset time due to spontaneous emission noise. Supported by NSF-REU.

LMA4 - **Geometric Phase on a Higher Order Poincaré Sphere,** *Stefan Evans[1,2], Giovanni Milione[1], and Robert Alfano[1]; 1) Institute for Ultrafast Spectroscopy and Lasers, City College of New York, New York, NY 10031, 2) Laser Teaching Center, Stony Brook University, Stony Brook, NY 11794.* We have investigated a geometric phase arising from cyclic transformations on a recently-proposed higher-order Poincaré sphere representation of vector states of polarization and total optical angular momentum. The measured geometric phase is shown to be directly proportional to the beam's total optical angular momentum.

LMA5 – **Identifying the Topological Charge of Optical Vortices through Diffraction**, *David Meltzer, Martin G. Cohen and John Noé; Laser Teaching Center, Stony Brook University, Stony Brook, NY 11794.* We studied how optical vortices propagate when diffracted by double slits and various apertures. Our results are in agreement with recent work by Sztul and Alfano, Hickmann *et al.* and others. In the near field diffraction pattern from a circular aperture we have seen what we believe is a new way to measure the topological charge. Supported by NSF-REU.

LMA6 – **Precise Internal Structuring of Glasses with Ultrashort Laser Pulses**, *Chris Nergard[1], Martin Richardson[1], Felix Dreisow[2], Stefan Nolte[2]; 1) University of Central Florida, Orlando, FL 32816, 2) Friedrich Schiller University, Jena, Germany.* We have created scattering structures in transparent materials using ultrafast lasers. Due to the micron scale size of the individual structures and the nature of their creation, true 3D geometry with a large variation in size is achievable. Supported by NSF IREU.

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LMA7 – **Compressive Sensing of Sparse Images,** *Gregory Howland[1], Laura Maguire[2], James Schneeloch[1], and John Howell[1]; 1) University of Rochester, Rochester NY 14627. 2) Harvey Mudd College, Claremont CA 91711.* A 2f imaging system was designed to investigate the number of photons needed to reconstruct a sparse image using compressive sensing. A digital micromirror device was used to control the sensing matrix. Higher light levels and larger numbers of measurements led to better reconstructions. Further analysis remains to be completed. Supported by NSF and DARPA.

LMA8 – **Two-photon, Two-Slit Interference Measurement Using a Parametric Down-Conversion Source,** *Caleb Coburn and M. Ware; Brigham Young University, Provo, UT 84602.* We report on the development of a two-photon, two-slit experiment where photons from parametric down conversion pairs are sent through single-mode fibers and then allowed to interfere spatially. This system displays second-order coherence effects that are not present in single-photon two-slit measurements.

LMA9 - **Characterizing Background Noise for Single-Electron Photon-Scattering Experiment,** *Brian Crenshaw, M. Ware, and J. Peatross; Brigham Young University, Provo, UT 84602.* We present noise background measurements associated with an experiment designed to measure single-photon radiation from individual electrons inside an intense laser focus. We show that it is possible to distinguish the extremely faint scattered signal from the 10^{18} photons in the energetic laser pulse.

LMA10 - **Second-Order and Spin Effects in an Analytical Model of an Electron in an Intense Laser Field,** *Nathan Gundlach and J. Peatross; Brigham Young University, Provo, UT 84602.* We extend an analytic approximation of a Gaussian electron wave packet in a relativistic electromagnetic field to include second-order refinements. We also investigate the behavior of spin as the particle interacts with the strong field.

LMA11 – **Progress on Optical Second-Harmonic Generation from Si Experiment,** *Charles Bevis[1], Galan Moody[1], Hebin Li[1], Daniel Dessau[1,] and Steven Cundiff [1,2]; 1) JILA, Boulder, CO 80309, 2) NIST, Boulder, CO 80305.* The design, production and results of our experiment intended to measure the second harmonic response from Si/SiO_2 interfaces will be discussed. Specifically, the temperature dependence of this signal will be explored. Preliminary results will be discussed. Supported by the NSF.

LMA12 – **Measurement of Plasma Density in an Ionizing Laser Focus,** *Joshua Olson, J. Peatross, and S. D. Bergeson; Brigham Young University, Provo, UT 84602.* We employ an interferometric technique to diagnose the plasma density in the focus of an intense laser ionizing argon. The plasma density is characterized as a function of delay after the ionizing pulse.

LMA13 – **Using Space-Charge Fields to Measure Plasma Density,** *Abigail Wilkins and S. D. Bergeson; Brigham Young University, Provo, UT 84602.* We discuss a method for determining densities of ultracold neutral plasmas. These plasmas expand due to space-charge effects. The expansion depends on the plasma's initial size and density. Changes in the expansion are measured using time-of-flight techniques. A model is used to determine the plasma density with reasonable accuracy.

LMA14 – **Amplitude and Frequency Noise of an Injection-Locked Ti:Sapphire Laser System,** *Dan Thrasher and S. D. Bergeson; Brigham Young University, Provo, UT 84602.* We report amplitude and frequency noise measurements of an injection-locked ti:sapphire laser which is used to amplify a low power diode laser to Watt-level output powers. Frequency noise is measured using heterodyne techniques. We find a frequency width of 360 kHz and an rms amplitude noise level of 1%.

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LMA15 - **Design, Construction, and Validation of a High Precision Photoacoustic Spectrometer,** *Daniel Hogan, Mitchio Okumura, David Long, and Thinh Bui; California Institute of Technology, Pasadena, CA 91125.* A photoacoustic spectrometer was designed and constructed to probe molecular oxygen's A-band transitions. Its high precision measurements will be used as reference data to support remote sensing. Supported by NASA.

LMA16 - **Dynamics of a Vertical-Cavity Surface-Emitting Laser Subject to Two-Mode Orthogonal Optical Injection,** *David W. Pierce, Yu Zhang, Ross Terada, and Hong Lin; Physics, Bates College, Lewiston, ME 04240.* We examined experimentally dynamical behaviors (e. g., polarization switching, frequency locking and periodic oscillation) of a VCSEL operating in the multi-transverse mode regime under orthogonal optical injection. The dynamics of the VCSEL is mapped in the parameter plane of frequency detuning versus injected power. Supported by Bates College.

LMA17 - **Towards All-Optical Stabilization Of Microcombs,** *Jessica Doehrmann[1], Scott Papp[2], and Scott Diddams[2]; 1) Bethel University, Arden Hills, MN 55112, 2) National Institute of Standards and Technology, Boulder, CO, 80305.* Optical frequency combs based on nonlinear parametric conversion in microresonators have been recently developed. We are working towards all-optical stabilization of microresonator frequency combs (microcombs) to the Doppler-free transitions of atomic Rb. Microcombs have applications in the development of chip-sized atomic clocks. Supported by NSF, NIST, DARPA, and NRC.

LMA18 - **Exploring Spatial Optical Memory using Slow Light in Ruby,** *Stephanie Swartz[1], Zhimin Shi[2], R.W. Boyd[1,2,3]; 1) Physics and Astronomy, University of Rochester, Rochester, NY 14627, 2) Institute of Optics, University of Rochester, Rochester, NY 14627, 3) Physics and School of Electrical and Computer Engineering, University of Ottawa, Ontario K1N 6N5, Canada.* We study experimentally the condition of achieving and improving slow light in ruby via coherent population oscillations (CPO). Specifically, we explore the conditions and requirements for realizing spatial optical memory using the CPO mechanism. Supported by the Defense Threat Reduction Agency.

LMA19 - **Low Bandgap Polymer Doping of P3HT/PCBM Solar Cells,** *Anne Ahlvers, Simon Tang, Zhongjian Hu, and Andre Gesquiere; University of Central Florida, Orlando, FL 32816.* Our experiment focuses on near-infrared photoresponse sensitization of P3HT/PCBM solar cells via low band gap polymer PCPDTBT, aiming at a broad absorption range. For devices made in the presence of DIO additive, with PCPDTBT doping level of 20 wt%, the device power conversion efficiency can be improved by 32%. Supported by NSF.

LMA20 - **Magneto-Optical Trap Diagnostics in Preparation for ^{87}Rb Excited State Lifetime Measurement**, *Karl Mayer and John Brandenberger; Lawrence University, Appleton, WI 54911.* An experiment to measure the $4^2D_{5/2}$ lifetime of ^{87}Rb in a magneto-optical trap is under development. Properties of trapped atoms, including density, speed, temperature, and collisional loss rate have been investigated. Supported by NSF and a Dale L. Skran, Sr. Summer Research Fellowship.

LMA21 – **Quantum Dots on Silicon Wafers,** *Michael Lueckheide[1], Rebecca Eells[1], Nourredine Melikechi[2], Yuri Markushin[2], and Jenny Magnes[1]; Vassar College, Poughkeepsie, NY 12604, 2) Delaware State University, Dover, DE 19901.* We study the formation of quantum dots on silicon wafers using Laser Induced Breakdown Spectroscopy, and the Fresnel Equations for reflection of light from a metal. Quantum dots have applications as ultra-fast, environmentally-friendly detectors, and in nanomedicine as carriers of treatments to specific parts of the body. Supported by URSI.

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LMA22 - **Study of Light Transmitted by an Engineered Diffuser™,** *T. Mittiga, B. Arnold, M. G. Cohen, H. Metcalf; Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794.* We studied the properties of an Engineered Diffuser™, an array of individually designed and arranged microlenses that produces a particular pattern of light (a square in our case). Using different color lasers, polarizations, beam diameters, and convergences, we measured output beam shape, convergence, polarization, and intensity distribution. Supported by ONR and NASA.

LMA23 – **Advanced Ultrafast Laser Concepts at the Tens of Terawatt Level,** *M.K. Carlson[1], A. Vaupel[1], B. Webb[2], N. Bodnar[2], L. Shaw[2], M. Richardson[2]; 1) Grove City College, Grove City, PA 16127, 2) CREOL, University of Central Florida, Orlando FL 32816.* We counteracted gain narrowing effects in an ultrafast CPA laser undergoing an upgrade. We used Fastlite's DAZZLER to shape the pulse spectrum before amplification. We automated the process in LABVIEW. The upgraded laser should demonstrate an increase in peak power from 10 TW to 17.8 TW using this process. Supported by NSF.

LMA24 - **Creating a Precisely-Tunable Single-Frequency Laser Source to Excite Whispering-Gallery Modes,** *Carrie Segal, Martin G. Cohen and John Noé; Laser Teaching Center, Stony Brook University, Stony Brook, NY 11794.* We hope to excite narrow whispering-gallery resonances in macroscopic glass spheres by evanescent-wave coupling to a precisely-tunable single-frequency laser source. As a first step, we used a 65-95 MHz AOM in single and double-pass configurations to shift the frequency of an incident 632.8 nm laser beam.

LMA25 - **Modeling a Hybrid Magnetic/Optical-Dipole Trap,** *Joseph Murphree, L. Suzanne Leslie and Nick Bigelow; University of Rochester, Rochester, NY 14627.* We created a computational model of a hybrid magnetic/optical-dipole trap for a dilute rubidium-87 gas to assist in installation of the experimental set-up, and to investigate an adiabatic cooling and compression procedure that will create a near-degenerate optically-contained atomic cloud. Supported by NSF.

LMA26 – **Characterization of Dense Ensembles of Nitrogen-Vacancy (NV) Centers in Diamond for Magnetometry,** *Maria Simanovskaia, Andrey Jarmola, Victor Acosta, Kasper Jensen, and Dmitry Budker; University of California, Berkeley, CA 94720.* NV centers in diamond are a promising system for magnetometry. The highest sensitivity could be achieved with dense samples having a long spin relaxation time. Single crystal diamonds rich in substitutional nitrogen were subjected to electron irradiation and annealing to make NV centers. Concentrations of impurities were measured. Supported by NSF and AFOSR/DARPA.

LMA27 – **Slow Light in Ruby Using a Two-Beam Geometry**, *Xiaowei Cai[1], Zhimin Shi[1], and Robert W. Boyd[1,2]; 1) Institute of Optics, 2) Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627.* We observe slow light in a ruby crystal in both single-beam and two-beam geometries. The two-beam geometry provides the freedom to control the relative polarizations of the pump and probe beams. We find, somewhat surprisingly, that changing the relative polarization has no significant effect on the magnitude of induced time delay. Supported by the Xerox Undergraduate Research Fellows Program.

LMA28 – **Seeking a Dirac Monopole in a Spinor Condensate,** *Saugat Kandel, Thomas Langin, Phyo Aung Kyaw, and David S. Hall; Amherst College, Amherst, MA 01002.* Magnetic monopoles are not observed in nature, but an analogous Dirac monopole in the vorticity field of a spinor Bose-Einstein condensate has been predicted by Pietilä and Möttönen. We attempt to experimentally realize this singular matter-wave structure by manipulating external magnetic fields applied to an optically trapped condensate. Supported by NSF.

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LMA29 – **Tellurite-Based Oxide Glasses for Novel MIR Fibers Applications with High Raman Gain**, *Rachel Anheier[1], Guillaume Guery[2], P. Wachtel[3], T. Cardinal[3], Kathleen Richardson[3], 1) University of Washington, Seattle, WA, 98105, 2) Université Bordeaux I, 33405 Talence Cedex, France, 3) School of Materials Science and Engineering, COMSET, Clemson University, Clemson, SC 29634.* Tellurite glasses have been evaluated for fiber optic applications but are limited by low loss and moderate strength. These limitations can be improved by compositional design and control of extrinsic impurities and defects. This study further quantifies efforts performed to decrease hydroxyl content in these glasses for future fiber applications. Supported by NSF-IREU.

LMA30 – **Construction of a Multi-Purpose High Power Tunable Laser for Use in Finding the Rovibrational Ground State of Ultracold NaCs**. *Susanna Todaro[1], Amy Wakim[2], Patrick Zabawa[2], Marek Haruza[2], and Nicholas P. Bigelow[2]; 1) Harvey Mudd College, Claremont, CA 91711 2) University of Rochester, Rochester, NY 14627.* We constructed a wavelength-tunable laser centered at 852 nm with a power range of 5mW – 250mW. This laser is effective for photoassociation of microkelvin Na and Cs atoms to create ultracold molecules. Supported by NSF.

LMA31 – **Preparation of Stable Laser Systems for Experiments in Quantum Computation,** *Jarom Jackson[1,2], Grant Biederman[2], George Burns[2], Aaron Hankin[2], Cort Johnson[2], Mike Mangan[2], L. Paul Parazzoli[2], and Peter Schwindt[2]; 1) Brigham Young University, Provo, UT 84602, 2) Sandia National Laboratories, Albuquerque, NM 87123.* As part of an effort to demonstrate adiabatic quantum computing with neutral cesium atoms, we have developed laser systems necessary for optical pumping, tuning hyperfine transitions via the light shift, and coherently exciting to Rydberg levels. Frequency stabilization to a cesium reference is achieved via offset or cavity transfer locks.

LMA32 – **Laser Vibrational Spectroscopy for Food Monitoring and the Detection of Different Food Additives,** *Marc Koehler[1,2], Yuan Liu[2], Matthieu Baudelet[2], Martin Richardson[2].* 1) *Physics and Astronomy, Dickinson College, Carlisle, PA 17013,* 2) *Townes Laser Institute, CREOL - University of Central Florida, Orlando, FL 32816.* Monitoring and analysis of food additives become an urgent need for ensuring food safety for consumers. The combination of Raman and infrared spectroscopic signatures were used to characterize different carotenoids for food coloring. Results showed identification and discrimination of tested carotenoid species were possible through Raman and IR spectroscopy. Supported by NSF-REU.

Group Photo Break 2:25 - 2:30 PM - - - PLEASE assemble at the designated place !!!

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ORAL SESSION – Glen Ellen Room - 2:30

Session LMD: 2:30 - 4:00 PM, Glen Ellen Room - Justin Peatross, Brigham Young, Presider

LMD1 - **Measurement of Total Internal Reflection from a Turbid Medium: Application to Particle Sizing**, *Kashika Goyal, Bradley Worth II, Sarabjot Makkar, Miao Dong, Lalit Bali, and Samir Bali; Miami University, Oxford, OH 45056.* Recently we introduced a new theoretical model for total internal reflection from a turbid medium. Here we confirm its validity in an aqueous solution of monodisperse polystyrene microspheres. Further, we determine particle size in an intravenous fat emulsion. Particle sizing in optical tissue is a topic of much debate recently. Supported by Petroleum Research Fund and Miami University.

LMD2 - **Measurement of Protein-Lipid Interactions using Fluorescence Correlation Spectrocopy**, *Harry Apostoleris and Carl Grossman; Physics and Astronomy, Swarthmore College, Swarthmore, PA 19081.* Using a confocal microscope, we performed fluorescence correlation spectroscopy on fluorescent dyes, small unilamellar vesicles and proteins. Initial measurements of the individual components separately determined the correlation times of the dye, protein and vesicles; subsequent measurements of a composite system determined the fraction of proteins bound to vesicles.

LMD3 - **Classical Simulation of Three-Body Recombination of Ultracold Atoms,** *Steve Ragole and Chris Greene; Physics and JILA, Univ. of Colorado, Boulder, CO 80301.* Three-body recombination is an important loss process in quantum gases. A classical simulation of the recombination process was developed and a 6D recombination cross section was calculated. Preliminary comparisons to quantum results are discussed. Supported partly by JILA NSF-PFC.

LMD4 - **Elastic Electron-Helium Scattering in a Nd:YAG Laser Field,** *Benjamin Nosarzewski[1], Bruno deHarak[2], and Nicholas Martin[3]; 1) Cornell University, Ithaca, NY 14853, 2) Illinois Wesleyan University, Bloomington, IL 61702 , 3) University of Kentucky, Lexington, KY 40506.* We measure stimulated single-photon emission from elastically scattered electrons as a function of laser polarization. Results are compared to Kroll-Watson approximation calculations. Supported by the NSF and an IWU ASD grant.

LMD5 – **Design and Construction of a Bose-Einstein Condensate Apparatus for Use in Optical-Lattice Experiments,** *Marc Tollin and Nathan Lundblad; Physics and Astronomy, Bates College, Lewiston, ME 04240.* We report progress towards BEC in ^{87}Rb, including vacuum chamber construction, design and construction of a spin-flip Zeeman slower, characterization of MOT loading and sub-Doppler cooling, and the results of magnetic trapping, evaporative cooling, and subsequent optical trapping. Supported by Bates College and AFOSR/DEPSCOR.

LMD6 - **Preparing and Projecting Quantum Spatial Modes**, *William Schubert and Enrique Galvez; Physics, Colgate University, Hamilton, NY 13346.* We created and diagnosed quantum superpositions of spatial modes, the building blocks of images, using spatial light modulators (SLMs). A Gaussian beam, diffracted into a superposition of spatial modes with orbital angular momentum, is examined by another SLM which diffracts it into a single mode fiber acting as a mode filter. Supported by the United States Air Force and NSF.

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ORAL SESSION – Glen Ellen Room - 4:30

Session LMG: 4:30 – 6:00 PM, Glen Ellen Room – Samir Bali, Miami Univ. of Ohio, Presider

LMG1 - **Cylindrically Polarized Solutions of Paraxial Maxwell's Equations,** *William Lewis, Reeta Vyas, and Surendra Singh; Physics, University of Arkansas, Fayetteville, AR 72701.* We use Maxwell's equations to calculate next order corrections to field components of cylindrically polarized Bessel-Gauss and Laguerre-Gauss beams in the paraxial regime and explore their effect on beam profile, divergence, and polarization with propagation. We also calculate relative contribution to beam power for different modes. Supported by SILO-SURF and Goldwater Scholarship.

LMG2 - **Single-Atom versus Collective-Atom Behavior in Laser High-Harmonic Generation,** *Jenny Lund and J. Peatross; Brigham Young University, Provo, UT 84602.* Laser-generated high harmonics typically employ many billions of atoms, where their coherent behavior is observed in the emission along the laser direction. We describe an experiment that measures single-photon emission of high harmonics out of the side of the laser to try to better characterize the incoherent emission from single atoms.

LMG3 - **Visualization of an Electron Wave Packet in an Intense Laser Field,** *Ryan Sandberg and J. Peatross; Brigham Young University, Provo, UT 84602.* We have generated three-dimensional movies of a free electron wave packet oscillating in a relativistic laser field. Interesting multi-peak structures, Lorenz drift, foreshortening of the packet, as well as differences between the cases of linearly and circularly polarized fields, are seen.

LMG4 - **Dynamic Diffraction Analysis and the Transformation of *C. elegans*,** *Rebecca Eells, Michael Lueckheide, Jenny Magnes, Kathleen Susman, Tzlil Rozenblat, and Rahul Kakurel; Vassar College, Poughkeepsie, NY 12604.* The diffraction patterns and transformations of *C. elegans* were used to study their movement and position as they passed through a laser beam. Supported by URSI, NSF-CREST.

LMG5 - **Constructing Ultrathin Optical Fibers for Cold Atom Trapping,** *A. K. Wood, D. Ornelas, J. A. Grover, J. E. Hoffman, Z. Kim, J. Lee, J. R. Anderson, A. J. Dragt, M. Hafezi, C. J. Lobb, L. A. Orozco, S. L. Rolston, J. M. Taylor, F. C. Wellstood; Joint Quantum Institute, Department of Physics and National Institute of Standards and Technology, University of Maryland, College Park, MD 20742.* We construct optical fibers with a submicron waist and controlled taper geometry. We plan to use these fibers to trap atoms in an evanescent field and position them less than 10 μm above a superconducting circuit for studies of hybrid quantum systems. Supported by NSF and MURI.

LMG6 - **Characterization of a Lithium Magneto-Optical Trap,** *Jessica Doehrmann, Jack Houlton, Dan Klemme, Sarah Venditto, and Chad Hoy; Bethel University, St. Paul, MN 55112.* We recently cooled and trapped $\sim 10^7$ lithium atoms in a magneto-optical trap. The laser source comprises a home-built external cavity diode laser, a semiconductor tapered amplifier and acousto-optic modulators for generating multiple laser detunings. We describe initial measurements such as temperature and atom number. Supported by Minnesota NASA Space Grant Consortium, CID Inc.

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EAST COAST OPTICAL TECHNOLOGIES

Symposium organized by Harold Metcalf and John Noé, Stony Brook University