Instrumentation for Quantum and Nonlinear Optical Imaging

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The funding obtained from this grant was used to purchase a tunable femtosecond laser system for use in the investigator’s research in quantum and nonlinear optical imaging. The funding arrived during the first year of the investigator's ARO project on this topic, and the availability of this new facility has contributed greatly to this research project. During the past year, we made the final selection of the laser system, placed the order for the laser, and installed it in our laboratory. The facility is now fully operational. The laser system was selected both because of its immediate relevance to our ARO-sponsored research program and because it is a very versatile laser system that can be tailored to a wide range of immediate and future applications. The short pulse duration produced by this system allows us to study high-intensity effects through use of only modest pulse energies. In this manner, we can avoid problems associated with laser damage and thereby be able to make use of the weaker but more versatile third-order nonlinear optical response for the generation of entangled and other quantum-correlated beams of light. The wavelength tunability of this laser system will allow us to make use of structural resonances in various material systems (such as PBG materials) to allow the large nonlinear response of such materials to be used for the generation of quantum states of light. This equipment will be useful for the education of a diverse group of students.

quantum states of light; quantum optics
Overview

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Equipment Purchased

Spectra-Physics Femtosecond laser system consisting of

(a) Millenia all solid state pump laser producing 5 watts cw at 532 nm

(b) Upgrade of an existing Tsunami femtosecond laser to produce required output specifications: less than 50 fs pulse duration, 76 MHz pulse repetition rate, 13 nJ per pulse, 1 W average power, tunable from 700 to 980 nm.

(c) Spitfire Ti:Sapphire regenerative amplifier producing pulses shorter than 130 fs with 1 mJ per pulse at a 1 kHz repetition rate, tunable from 750 to 840 nm.
(d) Evolution all-solid state intracavity-frequency doubled pulsed laser to pump with Spitfire amplifier.

(e) Femtosecond optical parametric amplifier (OPA) capable of continuous tuning from 1.1 to 3.0 micrometers and producing output pulses of less than 130 fs duration.

(f) Harmonic converter for the output of the OPA, capable of producing the second and fourth harmonics.

(g) Single-shot autocorrelator for characterizing the pulse duration of this system.

The total price of this system is $296,500. Of this amount, $170,000 was charged to ARO and the remainder was charged to an AFOSR equipment account.

**Participating Scientific Personnel**

Matthew King – Undergraduate

Ryan Bennink -- PhD Student, will graduate early 2004

Sean Bentley -- PhD Student, will defend late 2003; accepted faculty position at Adelphi University

Matthew Bigelow – PhD Student, will graduate within next year

John Heebner -- PhD Student, Graduated Spring 2003; presently at LLNL

Giovanni Piredda – PhD Student, will graduate 2004

Vincent Wong – PhD Student, will graduate 2004

Aaron Schwensberg – PhD Student

Colin O’Sullivan Hale – PhD Student

Petros Zerom – PhD Student

Ksenia Dolgaleva – PhD Student

Svetlana Lukishova -- Senior scientist working with group

Nick Lepeshkin -- Post Doc

Robert Boyd -- Professor

**Published Papers**


Observation of Ultra-Slow Light Propagation in a Ruby Crystal at Room Temperature M. S. Bigelow, N. N. Lepeshkin, R. W. Boyd, Phys. Rev. Lett. 90, 113903 (2003). A news article published in Nature describing this work can be found at the following web address http://www.nature.com/nsu/030324/030324-4.html


Papers in Review
Superluminal and Ultra-Slow Light Propagation in Room-Temperature Solids, R.W. Boyd, M.S. Bigelow, and N.N. Lepeshkin, to be published in the proceedings of ICOLS 03.


Equivalence of Interaction Hamiltonians in the Electric Dipole Approximation, K. Rzazewski and R.W. Boyd, accepted for publication in JMO.

Influence of Radiative Damping on the Optical-Frequency Susceptibility, P.W. Milonni and R.W. Boyd, accepted by PRA.

Filamentation of Ring Beams with Orbital Angular Momentum in Sodium Vapor, M.S. Bigelow, P. Zerom, and R.W. Boyd, submitted to PRL.


Conference Reports


Slow Light in Ruby and in Artificial Materials, Workshop on Quantum Optics, Institute for Theoretical Physics, University of California, Santa Barbara, CA July 23, 2002


New Concepts and Materials for Nonlinear Optics, presented at the Atomic, Molecular and Optical Physics Seminar present at SUNY Stony Brook June 11, 2002


Nanostructured Materials and Devices for Photonics, Robert W. Boyd, presented at the International Symposium on Photonic Science in the 21st Century, a part of the 50th Anniversary annual meeting of the Korean Physical Society, Hanyang University,
Seoul, Korea, October 25, 2002. Similar talks were also presented as Ewha Womans University and Korea University. *
Quantum and Nonlinear Optical Imaging, Presented at the ARO Optics Workshop, October 16, 2002. *
Quantum and Nonlinear Optical Imaging, Presented at the Workshop on Quantum Imaging and Metrology, Pasadena, CA November 14-15, 2002. *
Nanofabrication of Nonlinear Optical Materials and the Development of Ultrasensitive Disk-Microresonator Biosensors Presented at the Physical Sciences Laboratory, University of Maryland, November 20, 2002. *
Slow Light, Enhance Optical Nonlinearities, and Photonic Biosensors based on Quantum Coherence and on Artificial Optical Materials, presented at the 33rd Winter Colloquium on the Physics of Quantum Electronics, Snowbird Utah, January 9, 2003 **
New Materials and Interactions for Nonlinear Optics, presented February 4, 2003 as the Physics Colloquium at Ohio State University.
New Materials and Interactions for Nonlinear Optics, presented February 18, 2003 at Los Alamos National Laboratory.
New Materials and Interactions for Nonlinear Optics, presented as a seminar for first year graduate students at the University of Rochester Department of Physics and Astronomy, April 4, 2003.
Slow Light, Enhance Optical Nonlinearities, and Photonic Biosensors based on Quantum Coherence and on Artificial Optical Materials, presented April 9, 2003 at the joint Harvard University ITAMP, Atomic, Molecular, and Optical Physics Colloquium.
Nonlinear Optical Physics, Physics Colloquium, San Diego State University, May 2, 2003
Nonlinear Optical Physics, Physics Colloquium, University of California at Berkeley, May 5, 2003