Slow and Fast Light (SL)

Topical Meeting and Tabletop Exhibit

Collocated with:
Integrated Photonics and Nanophotonics Research and Applications (IPNRA)
Coherent Optical Technologies and Applications (COTA)
Quantum Entanglement and Decoherence: 3rd International Conference on Quantum Information (ICQI)

July 13-16, 2008

Boston Marriott Copley Place Hotel
Boston, Massachusetts, USA

Submission Deadline: March 10, 2008 (12:00 p.m. noon EDT; 16.00 GMT)
Hotel Reservation Deadline: June 11, 2008
Pre-Registration Deadline: June 26, 2008

General Chairs
Shun-Lien Chuang, *Univ. of Illinois at Urbana-Champaign, USA*
Gadi Eisenstein, *Technion Israel Inst. of Technology, Israel*

Program Chairs
Robert Boyd, *Univ. of Rochester, USA*
Jesper Moerk, *Technical Univ. Denmark, Denmark*

Due to increasing delays in securing visas to the US, we strongly encourage international attendees to begin this process as early as possible (but no later than three months before the meeting) to ensure timely processing. Please refer to the Letters of Invitation section of this website for additional information.

View the Meeting Archives for SL 2007 highlights (PDF 1.2MB).

Summer Optics and Photonics Congress

Join your colleagues July 13-16 in Boston, Massachusetts!

Collocated Topical Meetings

Coherent Optical Technologies and Applications (COTA)	Register Now
Integrated Photonics and Nanophotonics Research and Applications (IPNRA)	Register Now
Slow and Fast Light (SL)	Register Now
Quantum Entanglement and Decoherence: 3rd International Conference on Quantum Information (ICQI)	Register Now

Dates and Location	Important Deadlines
July 13-16, 2008 Boston Marriott Copley Place Hotel Boston, Massachusetts, USA	Submission Deadline Extended: March 10, 2008 (12:00 p.m. noon EDT; 16.00 GMT) Hotel Reservation Deadline: June 11, 2008 Pre-Registration Deadline: June 26, 2008

To find out more about how to exhibit at one of these meetings, please contact Anne Jones at 202.416.1942 or email ajones@osa.org. Reserve your exhibit space today!

Exhibitor

Discovery Semiconductor, Inc.
IPG Photonics
Optiwave
Photon Design
Photonics Spectra

Topics to be Discussed

COTA Topics

- Sources (i.e., high-power, narrow linewidth, phase-locked, stable, tunable)
- Phase preservation over temporal/spectral domains
- Receiver design
- Signal-detection techniques
- Phase locking techniques
- Phase estimation
- Phase, frequency and polarization modulators
- Phase-sensitive amplifiers
- Polarization management
- Data modulation formats/signaling/protocols
- Phase-sensitive systems

SL Topics

- **Physics of Light Control:**
  - Electromagnetically induced transparency
  - Coherent population oscillations
  - Four-wave mixing and parametric processes
  - Absorption or gain saturation
  - Stimulated Brillouin and Raman scattering
  - Passive and active manipulation in periodic structures and resonators
  - New schemes and physical effects
- **Materials and Engineered Structures for Light Control:**

- Free-space (spaceborne/airborne) communications
- Optical fiber communication systems and networks
- Analog links
- Secure communications
- Remote sensing
- Synthetic aperture Lidar/Ladar
- Fiber sensors
- Microsensing in spectroscopic applications
- Biosensing
- Statistical and cellular nature of biosensors
- Optical signal processing
- Arbitrary waveform generation and filtering
- A/D conversion
- Optical correlation
- Wavelength conversion

IPRNA Topics

- **Active Devices:** III-V semiconductor devices; silicon active devices; **LiNbO3 and other metal-oxide-based devices;** modulators; switches; wavelength converters; emitters; VCSELs; amplifiers; integrated scanners; quantum optoelectronic devices; complex circuits; new fabrication methods; materials and processing; reliability advances and issues.
- **Passive Devices and Integration: Dielectric, polymer, or semiconductor waveguide devices;** Integrated planar waveguides; active/passive integrated components; switches; variable optical attenuators; filters; resonators; integrated isolators and circulators; planar dispersion compensators; micro-optic components; optical interconnects; hybrid integration; reliability advances and issues; novel assembly and manufacturing techniques; emerging packaging technologies; testing and characterization; materials and fabrication technologies.

    - Metamaterials, including plasmonic structures
    - Photonic crystal waveguides and periodic structures
    - Optical fibers including holey fibers
    - Semiconductor nanostructures, including quantum wells and quantum dots
    - Saturable optical amplifiers and absorbers
    - BEC and hot vapor cells
    - Crystals and other solid-state materials
    - New materials and structures
- **Applications:**
    - Optical communications; all-optical buffers, routers, etc.
    - Microwave photonics; microwave filters and phased array systems
    - Sampling systems
    - Enhanced optical nonlinear response
    - Sensors and improved measurement systems
    - Figures-of-merit and fundamental limitations
    - New applications
- **Physics of Light Control:**
    - Electromagnetically induced transparency
    - Coherent population oscillations
    - Four-wave mixing and parametric processes
    - Absorption or gain saturation
    - Stimulated Brillouin and Raman scattering
    - Passive and active manipulation in periodic structures and resonators
    - New schemes and physical effects
- **Materials and Engineered Structures for Light Control:**
    - Metamaterials, including plasmonic structures
    - Photonic crystal waveguides and periodic structures
    - Optical fibers including holey fibers
    - Semiconductor nanostructures, including quantum wells and quantum dots
    - Saturable optical amplifiers and

- **Modeling, Numerical Simulation and Theory:** Optical-system modeling; numerical and semi-analytical methods for guided-wave optics; active, passive and nonlinear component modeling; WDM component design; simulation and modeling of photonic crystal, microcavity, and other high confinement structures; simulation and modeling of metallic and metallodielectric waveguides; advances in computational algorithms, physics and coupled models for integrated photonic circuits.
- **Nanophotonics:** Microcavity and other high confinement structures; photonic crystal waveguides and devices; photonic crystal fiber; **nano-engineered devices;** metallic and metallodielectric waveguide devices;resonators; filters; modulators; add-drop integrated optical circuits; light sources; quantum information; nano-MEMS; biophotonics; biological and chemical transducers and sensors; efficient mode matching; nanofabrication technology; growth and deposition approaches; self-organized methods; characterization tools on the nanoscale; **and nanoscale integration of planar, free-space, and mixed subsystems.**
- **Inhomogeneous Materials (e.g., Composite Dielectrics, Semiconductors, Metals and Metallodielectrics):** Anisotropic; dispersive; efficient light extraction; nonlinear optical materials; and dynamically configurable.

absorbers
    - BEC and hot vapor cells
    - Crystals and other solid-state materials
    - New materials and structures
- **Applications:**
    - Optical communications; all-optical buffers, routers, etc.
    - Microwave photonics; microwave filters and phased array systems
    - Sampling systems
    - Enhanced optical nonlinear response
    - Sensors and improved measurement systems
    - Figures-of-merit and fundamental limitations
    - New applications
- **Implementation Techniques:**
    - Experimental techniques
    - Theoretical techniques
    - Effective numerical simulation techniques
    - Experimental techniques
    - Theoretical techniques
    - Effective numerical simulation techniques

ICQI Topics

- Entanglement
- Decoherence
- Quantum imaging and lithography
- Quantum communication and cryptography, quantum channels, repeaters
- Algorithms, walks on graphs, spin chains, phase transitions, chaos and localization
- Emerging topics: cluster states, adiabatic quantum computing, topological quantum computing
- Optical and other implementations (linear optics, cavity QED, ion traps, solid state, etc.)
- Quantum state reconstruction, superresolution, metrology
- Storage and transfer of quantum information

About SL

July 13-16, 2008

Scope

We have been accustomed to thinking of the speed of light as a constant. Yet, over the past few years, it has become clear that the tools exist to slow down, speed up or even completely stop light propagation. This realization has certainly had a profound impact on the optics community from the point of view of fundamental science and has led to the suggestion and exploration of a number of practical applications within various areas.

This topical meeting will bring together physicists and engineers in order to present and discuss the latest achievements within the area of light-speed control. Exciting issues to be discussed include the physics and interpretation of various light-control schemes as well as the potentials and fundamental limitations of possible applications. The area is closely connected to research within structurally engineered materials, such as metamaterials, that allow fundamental control of light-matter interaction. The meeting will provide a forum for vital discussion among experimental and theoretical scientists.

Important Dates

Submission Deadline: March 3, 2008 (12:00 p.m. noon EST; 17.00 GMT)
Hotel Reservation Deadline: June 11, 2008
Pre-Registration Deadline: June 26, 2008

Slow and Fast Light Topics to Be Considered

The meeting will feature invited talks and consider submissions within the following (non-exclusive) list of topics:

Physics of Light Control:

- Electromagnetically induced transparency
- Coherent population oscillations
- Four-wave mixing and parametric processes
- Absorption or gain saturation
- Stimulated Brillouin and Raman scattering
- Passive and active manipulation in periodic structures and resonators
- New schemes and physical effects

Materials and Engineered Structures for Light Control:

- Metamaterials, including plasmonic structures
- Photonic crystal waveguides and periodic structures
- Optical fibers including holey fibers
- Semiconductor nanostructures, including quantum wells and quantum dots
- Saturable optical amplifiers and absorbers
- BEC and hot vapor cells
- Crystals and other solid-state materials
- New materials and structures

Applications:

- Optical communications; all-optical buffers, routers, etc.
- Microwave photonics; microwave filters and phased array systems
- Sampling systems
- Enhanced optical nonlinear response
- Sensors and improved measurement systems
- Figures-of-merit and fundamental limitations
- New applications

Implementation Techniques:

- Experimental techniques
- Theoretical techniques
- Effective numerical simulation techniques

Technical Program Committee

General Chairs

Shun-Lien Chuang, *Univ. of Illinois at Urbana-Champaign, USA*
Gadi Eisenstein, *Technion Israel Inst. of Technology, Israel*

Program Chairs

Robert Boyd, *Univ. of Rochester, USA*
Jesper Moerk, *Technical Univ. Denmark, Denmark*

Committee

Jose Capmany, *Univ. Politecnica de Valencia, Spain*
Shanhui Fan, *Stanford Univ., USA*
Daniel J. Gauthier, *Duke Univ., USA*
Lene Hau, *Harvard Univ., USA*
Michal Lipson, *Cornell Univ., USA*
Marin Soljacic, *MIT, USA*
Luc Thevenaz, *Ecole Polytechnique Fédérale de Lausanne, Switzerland*
Moshe Tur, *Tel-Aviv Univ., Israel*
Hailin Wang, *Univ. of Oregon, USA*

Discovery Semiconductor

119 Silva Street

Ewing, NJ 08628

Tel: +1 609.434.1311

Fax: +1 609.434.1317

Email: jaym@chipsat.com

www.chipsat.com

Discovery Semiconductors, Inc. is an industry leader in manufacturing ultrafast, high optical power handling InGaAs photodetectors, RF over fiber optical receivers, balanced optical receivers and several custom products for applications ranging from analog RF links to ultrafast digital communications. Discovery's instrumentation includes their Lab Buddy and Optical Coherent Receiver System. Contact: Jay Magbitang.

IPG Photonics

50 Old Webster Road

Oxford, MA 01540, USA

Tel: +1 877.980.1550 (toll free from US) or +1 508.373.1100

Fax: +1 508.373.1103

IPG manufactures fiber lasers and amplifiers for 1.0, 1.5 and 2.0 microns wavelengths. Output powers are from 100mWs to 50kW and available for CW or pulsed operation. For scientific applications linearly polarized and kHz linewidths products are available; for optical trapping, frequency doubling, free space communications. Industrial applications we provide diode Q-switched, and high power CW lasers; marking, welding, micro machining. Telecommunications we offer Raman and Erbium lasers and amplifiers; FTTH, CATV, ultra long haul. Contact Diana Ferreira, Sales. Tel: +1 508.373.1169, Fax: +1 508.373.1103. dferreira@ipgphotonics.com.

Optiwave Systems Inc.

7 Capella Court

Ottawa, Ontario

K2E 7X1 Canada

Tel. +1 613.224.4700 ext. 303

Fax. +1 613.224.4706

Email: richard.rambaran@optiwave.com

www.optiwave.com

Optiwave is the leading provider of innovative software design tools for optoelectronic and optical system engineers, hosting an unparalleled suite of award wining simulation software products. Design advanced passive and non-linear photonic components using sophisticated simulation environments. Model Surface plasma and anisotropic materials in a 64-bit simulation environment designed for multiprocessor and multicore computing platforms. Download your free trial at www.optiwave.com.

(turn over for Photon Design and Photonics Spectra)

Photon Design

34 Leopold St.

Oxford, OX4 1TW

United Kingdom

Tel: +44 1865 324990

Fax: +44 1865 324991

Email: info@photond.com

www.photond.com

Photon Design, founded 1992, provides a wide range of photonics software for integrated and fibre-based component design. Products include FIMMPROP–our revolutionary bi-directional optical propagation tool, FIMMWAVE – our famous mode solver, PICWave - our new active/passive photonic-IC circuit simulator, CrystalWave–photonic crystal simulator, OmniSim–general purpose 3D FDTD simulator.

Photonics Spectra

2 South Street, Berkshire Common

Pittsfield, MA 01201

Tel: +1 413.499.0514

Fax: +1 413.442.3180

photonics@laurin.com

www.Photonics.com/spectra

Photonics Spectra is the leading photonics magazine serving industries that use photonic technology: lasers, imaging, fiber optics, optics, electro-optics, and photonic component manufacturing. It presents the latest news articles and in-depth reports on photonics technology. It is distributed free to those who use or apply photonics.

The Organizers for the Summer Optics and Photonics Congress

wish to thank the following US Government Agencies

for their generous contributions:

COTA

Air Force Office of Scientific Research

ICQI

Air Force Office of Scientific Research

IPNRA

Defense Advanced Research Projects Agency/

Army Research Laboratory

SL

Air Force Office of Scientific Research

Special Events

Joint Plenary Sessions

Monday, July 14
8:00 a.m.–10:00 a.m.
Salon E

Photonic Entanglement in Quantum Communication and Quantum Computation
Anton Zeilinger, Univ. of Vienna, Austria
In the 1970s Anton Zeilinger started his work on the foundations of quantum mechanics with neutron interferometry. These experiments included confirmation of the sign change of a spinor phase upon rotation, precision tests of the linearity of the Schrödinger equation, and many other fundamental tests.

Going beyond single-particle phenomena, Zeilinger became interested in quantum entanglement, where his most significant contribution is the discovery of what is today called “GHZ states” and their experimental realization. These were the first instances of multi-particle entanglement ever investigated. Such states have become essential in fundamental tests of quantum mechanics and in quantum information science. Since then, Zeilinger has performed many experiments with entangled photons, including quantum teleportation, quantum cryptography, all-optical one-way quantum computation and a number of quantum gates. In single-particle interference, he has performed a number of experiments in atom interferometry and in quantum interference of large molecules, like C60 and C70. These included very detailed studies of quantum decoherence. The technological progress in all these fields is making new fundamental tests possible. Most recently, Zeilinger became interested in tests of Leggett-type nonlocal theories and in fundamental phenomena in quantum entanglement of ultracold atoms, to name two examples.

The most important stages in the career of Anton Zeilinger include the Technical University of Vienna, MIT, the Technical University of Munich, the University of Innsbruck, the Collège de France, the University of Vienna and the Austrian Academy of Sciences.

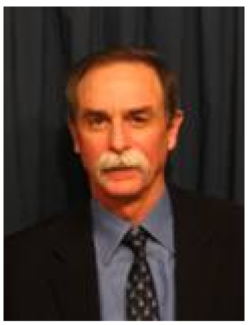
The Intimate Merger of Photonics and Computing
Ashok V. Krishnamoorthy, SUN Microsystems, USA
Ashok V. Krishnamoorthy currently serves as Distinguished Engineer and Senior Director with the Sun Microsystems Microelectronics Physical Sciences Center in San Diego, California. He leads Sun’s photonics technology development effort and is the principal investigator on their DARPA UNIC program. Prior to this he was with AraLight as its President and CTO as part of a Lucent spinout, where he was responsible for leading product design and development for AraLight’s optical interconnect products. He has also served as entrepreneur-in-residence at Lucent’s New Venture group, and as a member of technical staff in the Advanced Photonics Research Department of Bell Labs where he investigated methods of integrating optical devices to Silicon VLSI circuits. He received the B.S. in engineering (Honors) from the California Institute of Technology, the M.S. in electrical engineering from the University of Southern California, and the Ph.D. in applied physics from the University of California at San Diego.

Dr. Krishnamoorthy serves on the technical advisory board for several optical technology start-ups and venture funds, and as a distinguished lecturer for IEEE/LEOS. He holds 40 patents and has contributed 150 technical publications, five book chapters and presented over 45 invited talks at international technical conferences. For his contributions to optoelectronics, and his service to technical societies, the Eta Kappa Nu society named him an outstanding young electrical engineer in 1999. He was awarded the 2004 international prize in optics by the ICO for his technical contributions to optics. He has also won several team awards, including Computerworld’s 2005 horizon award for innovation. Most recently, he received the 2006 chairman’s award for innovation by Sun Microsystems for his work on silicon optical interconnects for computing systems.

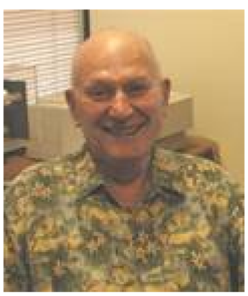
Tuesday, July 15
8:00 a.m.–10:00 a.m.

Salon E

Electro-Optic Modulation of Photons and Biphotons
Stephen E. Harris, Stanford Univ., USA.
Professor Stephen E. Harris received his B.S. in electrical engineering from Rensselaer Polytechnic Institute in 1959. In 1963 he became a member of the Stanford University faculty where he is now the Kenneth and Barbara Oshman Professor of Engineering with appointments in electrical engineering and applied physics. Professor Harris has advised about 60 Ph.D. students and is known for contributions to quantum optics, nonlinear optics and laser science.



Entanglement, Information Processing and Decoherence in Trapped Atomic Ions
David Wineland, NIST, USA
David Wineland received a bachelor's degree from the University of California at Berkeley in 1965 and his Ph.D. from Harvard University in 1970. After a postdoctoral appointment at the University of Washington, he joined NBS (now NIST), where he is the leader of the Ion-Storage Group (http://www.bldrdoc.gov/timefreq/ion) in the Time and Frequency Division at Boulder. The group's research has focused on laser cooling and spectroscopy of trapped atomic ions with applications to atomic clocks, quantum-limited metrology and quantum state control.



Coherence Cloning and Phase Controlled Apertures Using Optical Phase-Lock Loops
Amnon Yariv, Caltech, USA
Amnon Yariv is the Martin and Eileen Summerfield Professor of Applied Physics and Electrical Engineering at Caltech. He obtained the B.S. (1954), M.S. (1956) and Ph.D. (1958) in electrical engineering from the University of California at Berkeley. He went to Bell Telephone Laboratories, Murray Hill, New Jersey in 1959, joining the early stages of the laser effort. He came to the California Institute of Technology in 1964.

On the technical and scientific side, he took part (with various co-workers) in the discovery of a number of early solid-state laser systems, in proposing and demonstrating the field of semiconductor integrated optics, the suggestion and demonstration of the semiconductor distributed feedback laser and in co-pioneering the field of phase conjugate optics. His present research efforts are in the areas of nonlinear optics, semiconductor lasers and integrated optics with emphasis on communication and computation.

Dr. Yariv is a member of the American Physical Society, Phi Beta Kappa, the American Academy of Arts and Sciences, the National Academy of Engineering, the National Academy of Sciences, a Fellow of the Institute of Electrical and Electronics Engineers and the Optical Society of America. He was the recipient of the 1980 Quantum Electronics Award of the IEEE, the 1985 University of Pennsylvania Pender Award, the 1986 Optical Society of America Ives Medal, the 1992 Harvey Prize, the 1998 OSA Beller Medal, an honorary doctorate, December 2000 from Ben Gurion University of the Negev, Israel and received a Laurea Honoris Causa, September 2007 from Universitá degli Studi dell'Aquila. Dr. Yariv was a founder and chairman-of-the-board of ORTEL Corporation (acquired by Lucent Technologies in 1998), and is a founder and a board member of a number of startup companies in the optical communications field.

Joint Poster Session

Monday, July 14
6:30 p.m.–8:00 p.m.
Salon F
A total of 79 posters will be presented during the joint poster session.

Congress Reception

Tuesday, July 15
6:30 p.m.–8:00 p.m.
Salon F
Join your colleagues for a joint reception to include attendees of all four meetings. Hors d'oeuvres, beer and wine will be served.

IPNRA Special Session and Roundtable Discussion

ITuE • Computer Aided Design for Integrated and Nano Photonics
Tuesday, July 15
4:30 p.m.–6:30 p.m.
Salon A/B

A special session for photonic commercial software developers, followed by a roundtable discussion is planned as part of IPNRA and all congress registrants are welcome to attend. The main photonic software companies such as RSoft, Optiwave, Photon Design and JCMWave will be represented. Topics to be discussed include:

- Technical challenges
- Assessment and validation of algorithms/software (standardization/normalization)
- Convergence of technologies (wireless-photonics, displays-photonics, etc.)

The session will conclude with a roundtable discussion focusing on additional non-technical aspects such as:

- Interaction with academy
- Job opportunities
- Vision of the market

Invited presentations:

Addressing Photonic Applications via a Broad Range of Integrated Simulation Methods, *Robert Scarmozzino, E. Heller, M. Bahl; RSoft Design Group, Inc., USA*

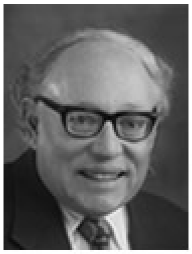
Designing Active Photonic Integrated Circuits Using TDTW, *Dominic F. Gallagher; Photon Design, UK*

Multi-Disciplinary Simulation of Electro-Opto-Thermal Networks Using a SPICE-Like Framework, *Pavan Gunupudi1, Tom Smy1, Jackson Klein2, Jan Jakubczyk2; 1Carleton Univ., Canada, 2Optiwave Systems, Canada*

JCMsuite: An Adaptive FEM Solver or Precise Simulations in Nano-Optics, *Sven Burger, Lin Zschiedrich, Jan Pomplun, Frank Schmidt; JCMwave, Germany*

Invited Speakers

Slow Light Plenary Speaker



Photonic Entanglement in Quantum Communication and Quantum Computation, *Stephen E. Harris; Stanford Univ., USA.*

Professor Stephen E. Harris received his B.S. in Electrical Engineering from Rensselaer Polytechnic Institute in 1959. In 1963 he became a member of the Stanford faculty where he is now the Kenneth and Barbara Oshman Professor of Engineering with appointments in Electrical Engineering and Applied Physics. Professor Harris has advised about 60 Ph.D. students and is known for contributions to quantum optics, nonlinear optics, and laser science.

Slow Light Invited Speakers

SMA1, **Title to Be Announced,** *Peter Knight; Imperial College, UK.*

SMA2, **Stationary Light and Bose-Einstein Condensation of Slow-Light Polaritons,** *Michael Fleischhauer; Univ. of Kaiserslautern, Germany.*

SMB1, **Optical Cloaking and "Fast Light",** *Vladimir M. Shalaev, W. Cai, U. Chettiar, A. V. Kildishev; Purdue Univ., USA.*

SMB2, **Plasmon Assisted Transparency in Metallodielectric Resonators,** *Miriam Deutsch; Univ. of Oregon, USA.*

SMC1, **High-Performance Gbit/s Data Transmission through Slow Light Elements,** *Alan E. Willner; Univ. of Southern California, USA.*

SMC2, **How to Build an Optical Buffer for IP Packets,** *Rodney S. Tucker; Univ. of Melbourne, Australia.*

STuA1, **Slow and Fast Light in THz Regime,** *Forrest G. Sedgwick; Univ. of California at Berkeley, USA.*

STuA2, **Mid-Infrared Semiconductor Metamaterials,** *Claire Gmachl; Princeton Univ., USA.*

STuB1, **Grating Induced Transparency (GIT) and the Dark Mode in Optical Waveguides,** *Amnon Yariv, Hsi-Chun Liu; Caltech, USA.*

STuB2, **1 Byte Reconfigurable Integrated Optic Delay Line,** *Andrea Melloni; DEI, Italy.*

STuC1, **Slow Light Based on Stimulated Brillouin Scattering: New Possibilities and Open Questions,** *Miguel Gonzalez-Herraez; Dept. of Electronics, Univ. of Alcala, Spain.*

STuC2, **Using Nonuniform Fiber to Generate Slow Light via Stimulated Brillouin Scattering,** *Xiaoyi Bao; Univ. of Ottawa, Canada.*

SWA1, **Loss, Noise, Power Dissipation: How They Affect Performance of Slow Light Devices,** *Jacob B. Khurgin; Johns Hopkins Univ., USA.*

SWA2, **Fundamental Limits in Linear One-Dimensional Slow Light Structures,** *David A. B. Miller; Stanford Univ., USA.*

SWB1, **Broad Bandwidth Slow Light, Enabled by Surface Plasmons and Polaritons,** *Marin Soljacic; MIT, USA.*

SWB2, **Slow Light in Photonic-Crystal Waveguides and Cavities,** *Solomon Assefa, Fengnian Xia, William M. J. Green, Yurii Vlasov; IBM TJ Watson Res. Ctr., USA.*

SWC1, **Slow Light Media Based on Ultrahigh-*Q* Nanocavities,** *Masaya Notomi, T. Tanabe, E. Kuramochi, H. Taniyama; NTT Basic Res. Labs, Japan.*

SWC2, **Impact of Nonlinearity and Disorder on Slow Modes in Membrane Photonic Crystals,** *Alfredo Rossi[1], S. Combrié[1], Q. V. Tran[1], C. Husko[1], G. Vadalà[1], P. Hamel[2], R. Gabet[2], Y. Jaouën[2], A. Parini[3], Y. Gottesman[3], F. Raineri[4]; [1]Thales Res. and Technology, France, [2]GET/Telecom Paris, France, [3]Inst. Natl. des Télécommunications, France, [4]Lab de Photonique et de Nanostructures, France.*

SWD1, **Ultralong Tunable Delays,** *Alexander Gaeta; Cornell Univ., USA.*

Agenda of Sessions

	Salon E	Salons A/B	Salons C/D	Salon G	Salons H–J
Sunday, July 13					
4:00 p.m.–6:00 p.m.	Registration Open (Atrium Foyer)				
Monday, July 14					
7:00 a.m. – 6:00 p.m.	Registration Open (Atrium Foyer)				
8:00 a.m.–10:00 a.m.	JMA • Monday Plenary Session				
10:00 a.m.–10:30 a.m.	Coffee Break (Salon Foyer)				
10:30 a.m.–12:30 p.m.	IMA • Transmitters and Other Devices	IMB • Plasmonic Structures	CMA • Components I	SMA • EIT and Quantum Information	QMA • Entanglement I
12:30 p.m.–2:00 p.m.	Lunch Break				
2:00 p.m.–4:00 p.m.	IMC • Active Silicon Devices	IMD • Photonic Crystal Cavities and Waveguides	CMB • Waveform Synthesis	SMB • Metamaterials	QMB • Entanglement II
4:00 p.m.–4:30 p.m.	Coffee Break (Salon Foyer)				
4:30 p.m.–6:30 p.m.	IME • Silicon Photonic Components	IMF • Nanophotonic Structures	CMC • Components II	SMC • Applications in Optical Communications	QMC • Optical and Other Implementations I
6:30 p.m.–8:00 p.m.	JMB • Joint Poster Session (Salon F)				
Tuesday, July 15					
7:30 a.m.–5:00 p.m.	Registration Open (Atrium Foyer)				
8:00 a.m.–10:00 a.m.	JTuA • Tuesday Plenary Session				
10:00 a.m.–10:30 a.m.	Coffee Break (Salon Foyer)				
10:30 a.m.–12:30 p.m.	ITuA • Planar Lightwave Circuits and Filters	ITuB • Microlasers and Emission	CTuA • Imaging I	STuA • Semiconductor Structures and CPO Effects	QTuA • Entanglement III
12:30 p.m.–2:00 p.m.	Lunch Break				
2:00 p.m.–4:00 p.m.	ITuC • Sensors and Lightwave Circuits	ITuD • Multi-Core Photonics and Simulations	CTuB • Imaging II	STuB • Gratings and Coupled Resonators	QTuB • Quantum Imaging and Emerging Topics
4:00 p.m.–4:30 p.m.	Coffee Break (Salon Foyer)				
4:30 p.m.–6:30 p.m.		ITuE • Computer Aided Design for Integrated and Nano Photonics	CTuC • Analog Photonics	STuC • Slow Light in Optical Fibers	QTuC • Decoherence and Algorithms
6:30 p.m.–8:00 p.m.	Conference Reception (Salon F)				
Wednesday, July 16					
7:30 a.m. – 5:00 p.m.	Registration Open (Atrium Foyer)				
8:00 a.m.–10:00 a.m.	IWA • Micro-Resonators and Lightwave Devices	IWB • Modeling Optical Fibers and Waveguides	CWA • Coherent Communications I	SWA • Fundamental Limitations and New Applications	QWA • Entanglement IV
10:00 a.m.–10:30 a.m.	Coffee Break (Salon Foyer)				
10:30 a.m.–12:30 p.m.	IWC • Photonic Integration	IWD • Solar Cells and Nanostructures	CWB • Coherent Communications II (ends at 12:45 p.m.)	SWB • Metamaterials and Photonic Crystals	QWB • Optical and Other Implementations II, Quantum State Reconstruction, Storage I
12:30 p.m.–2:00 p.m.	Lunch Break				
2:00 p.m.–4:00 p.m.	IWE • Active Structures	IWF • Simulations, Photonic Devices and Materials	CWC • Coherent Communications III (ends at 4:15 p.m.)	SWC • Photonic Crystals	QWC • Quantum Communication
4:00 p.m.–4:30 p.m.	Coffee Break (Salon Foyer)				
4:30 p.m.–6:30 p.m.	IWG • Waveguide Components (ends at 5:45 p.m.)	IWH • Resonant Structures (ends at 5:45 p.m.)		SWD • Slow Light in Atomic Vapors (ends at 6:00 p.m.)	QWD • Metrology, Storage II and Transfer of Quantum Information; Emerging Topics

Slow and Fast Light (SL)

Abstracts

• Sunday, July 13 •

Atrium Foyer
4:00 p.m.–6:00 p.m.
Registration Open

• Monday, July 14 •

Atrium Foyer
7:00 a.m.–6:00 p.m.
Registration Open

JMA • Joint Plenary Session I

Salon E
8:00 a.m.–10:00 a.m.
JMA • Joint Plenary Session I

8:00 a.m.
Opening Remarks, *Conference Chairs (COTA, Slow Light, and ICQI).*

8:15 a.m.
ICQI Plenary
Photonic Entanglement in Quantum Communication and Quantum Computation, *Anton Zeilinger; Univ. Wien, Austria.*

9:00 a.m.
Opening Remarks, *Conference Chair (IPNRA).*

9:05 a.m.
IPNRA Plenary
The Intimate Merger of Photonics and Computing, *Ashok V. Krishnamoorthy, SUN Microsystems, USA.*

Salon Foyer
10:00 a.m.–10:30 a.m.
Coffee Break

SMA • EIT and Quantum Information

Salon G
10:30 a.m.–12:30 p.m.
SMA • EIT and Quantum Information
Lene Vestergaard Hau; Harvard Univ., USA, Presider

SMA1 • 10:30 a.m. **Invited**
Title to Be Announced, *Peter Knight; Imperial College, UK.* No abstract available.

SMA2 • 11:00 a.m. **Invited**
Stationary Light and Bose-Einstein Condensation of Slow-Light Polaritons, *Michael Fleischhauer; Univ. of Kaiserslautern, Germany.* Stationary light with 3-D confinement based on EIT is discussed and Bose condensation of the associated quasiparticles at large temperatures is proposed. Incoherent generation, thermalization and detection methods for the condensate are analyzed.

SMA3 • 11:30 a.m.
Slow Light with Fourth Order Fields, *Curtis J. Broadbent, Praveen K. Vudyasetu, Ryan M. Camacho, Ran Xin, John C. Howell; Univ. of Rochester, USA.* We demonstrate experimentally the preservation of entanglement between delayed and non-delayed members of energy-time entangled biphotons, as well as the preservation of fourth order temporal coherence of thermal light with a delayed version of itself.

SMA4 • 11:45 a.m.
Electromagnetically Induced Transparency (EIT) and Slow Light in a ^{4}He* Hot Atomic Vapor, *Fabienne Goldfarb[1], Joyee Ghosh[1,2], Martin David[1], Jerome Ruggiero[1], Thierry Chaneliere[1], Jean-Louis Le Gouet[1], Herve Gilles[3], Rupamanjari Ghosh[2], Fabien Bretenaker[1]; [1]Lab Aime Cotton, Ctr. Natl. de la Res. Scientifique, France, [2]Jawaharlal Nehru Univ., India, [3]Ctr. de Res. sur les Ions, les Materiaux et la Photonique, France.* EIT and light velocities as low as 7000 $m.s^{-1}$ were observed at 1.083 µm using a ^{4}He* cell at room temperature. The 1 GHz Doppler broadening opens the door to broadband radar applications.

SMA5 • 12:00 p.m.
Observation of Electromagnetically Induced Transparency in a Quantum Dot Ensemble, *Saulius Marcinkevicius[1], Aleksander Gushterov[2], Johann P. Reithmaier[2]; [1]Royal Inst. of Technology, Sweden, [2]Kassel Univ., Germany.* Electromagnetically induced transparency (EIT) based on exciton spin transitions is observed in InGaAs quantum dots. Inhomogeneous broadening of the quantum dot ensemble, detrimental for EIT, is effectively reduced by using spectrally narrow pulses.

SMA6 • 12:15 p.m.
Manipulate Retrieval of Stored Light Pulses, *Yong-Fan Chen[1], Ite A. Yu[2]; [1]Dept. of Physics, Natl. Cheng Kung Univ., Taiwan, [2]Dept. of Physics, Natl. Tsing Hua Univ., Taiwan.* We have experimentally demonstrated that the width, frequency, and polarization of stored light pulses can be manipulated by controlling the retrieval process. The manipulation of stored light pulses may facilitate the application of optical communications.

12:30 p.m.–2:00 p.m.
Lunch Break

SMB • Metamaterials

Salon G
2:00 p.m.–4:00 p.m.
SMB • Metamaterials
Shanhui Fan; Stanford Univ., USA, Presider

SMB1 • 2:00 p.m. **Invited**
Optical Cloaking and "Fast Light," *Vladimir M. Shalaev, W. Cai, U. Chettiar, A. V. Kildishev; Purdue Univ., USA.* Recent advances in metamaterial research have provided us with a blueprint for cloaking capabilities. We analyze practical designs to convert concepts into real-life devices along with limitations to cloaking and its relation to "fast light."

SMB2 • 2:30 p.m. **Invited**
Plasmon Assisted Transparency in Metallodielectric Resonators, *Miriam Deutsch; Univ. of Oregon, USA.* We present a theoretical study of light scattering in spherical metallodielectric multi-layered particles and their ordered assemblies. A tunable electromagnetic transparency and possible left-handed optical response are discussed.

SMB3 • 3:00 p.m.
Stopped Light in Negative-Index Metamaterial Heterostructures, *Kosmas L. Tsakmakidis, Ortwin Hess; Advanced Technology Inst. and Dept. of Physics, Faculty of Engineering and Physical Sciences, Univ. of Surrey, UK.* Lightwaves guided along an adiabatically tapered negative-index heterostructure can efficiently be brought to a complete halt. We prove this conclusion by means of, both, full-wave and pertinent ray-tracing analyses.

SMB4 • 3:15 p.m.
Slow Surface Plasmons, *Eric R. Eliel, Nikolay V. Kuzmin, Barry J.G. van der Meer, Anna L. Tchebotareva, Gert W. 't Hooft; Leiden Univ., Netherlands.* We have studied surface plasmons propagating along a smooth silver-glass interface at energies up to 2.6 eV. These short-wavelength plasmons, with an effective wavelength of 260 nm, travel at a group velocity equal to c/3.

SMB5 • 3:30 p.m.
Slow Light in "Zero Thickness" Metamaterials, *Nikitas Papasimakis[1], Vassili A. Fedotov[1], Sergey L. Prosvirnin[2], Nikolay I. Zheludev[1]; [1]Optoelectronics Res. Ctr., Univ. of Southampton, United Kingdom, [2]Inst. of Radio Astronomy, Natl. Acad. of Sciences of Ukraine, Ukraine.* We show for the first time that a classical analogue of EIT can be realized in "zero thickness" planar metamaterials (meta-surfaces) resulting in substantial delay of propagating electromagnetic pulses.

SMB6 • 3:45 p.m.
Split Band Edge Structures and Negative Index, *John O. Schenk[1], Robert P. Ingel[1], Michael A. Fiddy[1], Weiguo Yang[2]; [1]Univ. of North Carolina at Charlotte, USA, [2]Western Carolina Univ., USA.* Highly anisotropic periodic waveguide structures show gigantic field enhancements near a split band-edge due to low group velocities. An effective negative index regime is observed, leading to strong but localized field emission around the waveguide.

Salon Foyer
4:00 p.m.–4:30 p.m.
Coffee Break

SMC • Applications in Optical Communications

Salon G
4:30 p.m.–6:30 p.m.
SMC • Applications in Optical Communications
Moshe Tur; Tel-Aviv Univ., Israel, Presider

SMC1 • 4:30 p.m. **Invited**
High-Performance Gbit/s Data Transmission through Slow Light Elements, *Alan E. Willner; Univ. of Southern California, USA.* This paper will highlight various systems issues that relate to transmitting high-speed data through slow-light delay elements, such as: (i) data-pattern-dependent penalties, (ii) PSK and QPSK data signals, and (iii) synchronization and multiplexing.

SMC2 • 5:00 p.m. **Invited**
How to Build an Optical Buffer for IP Packets, *Rodney S. Tucker; Univ. of Melbourne, Australia.* We describe the design of Internet Protocol (IP) buffers for optical packet switches. We show that slow light delay lines and ring resonator arrays show potential, but a number of key challenges remain.

SMC3 • 5:30 p.m.
Large Multi Gbit/s Delays Generated in an All-Optical Tunable Delay Line Preserving Wavelength and Signal Bandwidth, *Sanghoon Chin, Luc Thévenaz; Ecole Polytechnique Fédéral de Lausanne, Switzerland.* Large all-optical tunable delays are generated in a dispersive fiber by double wavelength conversion through cross gain modulation in semiconductor optical amplifiers. A 156 ps pulse train is continuously delayed up to 14 ns.

SMC4 • 5:45 p.m.
All-Optical Tunable Delay Line Based on Soliton Self-Frequency Shift for 10 Gbit/s Data Modulated RZ Pulses with the Assist of Pulse Compression, *Tomochika Kanou, Takashi Kunihiro, Akihiro Maruta; Osaka Univ., Japan.* We propose a novel all-optical tunable delay line based on soliton self-frequency shift for 10 Gbit/s data modulated RZ

pulses with the assist of pulse compression and experimentally demonstrate the error free operation.

SMC5 • 6:00 p.m.
Performance of a Silicon-Microring Slow-Light Delay Line for Advanced Modulation Formats, *Qiang Li[1], Fangfei Liu[1], Ziyang Zhang[2], Min Qiu[2], Tong Ye[1], Yikai Su[1]; [1]Shanghai Jiao Tong Univ., China, [2]Royal Inst. of Technology, Sweden.* We experimentally demonstrate a delay line in silicon microring resonator with a 20-μm radius. The delay performances of six advanced modulation formats are investigated, including NRZ, RZ, DPSK, CSRZ, RZ-DB and RZ-AMI.

SMC6 • 6:15 p.m.
Simulation of Sub-Wavelength Metal Gratings for On-Chip Applications in Optical Communications, *Erica D. Lively, Daniel J. Blumenthal; Univ. of California at Santa Barbara, USA.* Finite-difference time-domain (FDTD) and finite element method (FEM) techniques are used to demonstrate the potential of integrating sub-wavelength metal gratings onto an InP based material platform. Dispersion relations and pulse propagation are simulated.

JMB • Joint Poster Session

Salon F
6:30 p.m.–8:00 p.m.
JMB • Joint Poster Session

JMB10
Enhancement of Brillouin Slow-Light in Optical Fibers through Optical Pulse Shaping, *Sanghoon Chin, Luc Thévenaz; Ecole Polytechnique Fédéral de Lausanne, Switzerland.* The impact of pulse shape is studied in order to enhance time delaying in Brillouin slow-light. An exponential-like pulse with 14-ns FWHM duration is delayed up to 31-ns in a 27 MHz wide Brillouin resonance.

JMB11
Experimental Observation of Pulse Delay and Speed-up in Cascaded Quantum Well Gain and Absorber Media, *Per L. Hansen, Mike V. D. Poel, Kresten Yvind, Jesper Mørk; Technical Univ. of Denmark, Denmark.* Slow-down and speed-up of 180 fs pulses in semiconductor waveguides beyond the existing models is observed. Cascaded gain and absorbing sections is shown to provide significant temporal pulse shifting at near constant output pulse energy.

JMB12
Chirp Dependence of Filter Assisted Slow and Fast Light Effects in Semiconductor Optical Amplifiers, *Weiqi Xue[1], Yaohui Chen[1], Filip Öhman[1], Salvador Sales[2], Jesper Mørk[1]; [1]Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark, [2]Inst. of Telecommunications and Multimedia Applications, Univ. Politécnica de Valencia, Spain.* We demonstrate that the initial optical phase difference between the carrier and sidebands will strongly influence the final RF phase shift induced by filter assisted slow and fast light effects in semiconductor optical amplifiers.

JMB13
Comparison of EIT Schemes in Semiconductor Quantum Dots, *Jakob Houmark[1], Torben R. Nielsen[2], Jesper Mørk[2], Antti-Pekka Jauho[1]; [1]Dept. of Micro- and Nanotechnology, Technical Univ. of Denmark, Denmark, [2]Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We compare the slowdown capabilities of different EIT schemes in a transient regime using a many-body approach. The V scheme is preferable as it requires the lowest pump power to achieve reasonable slowdown factors.

JMB14
Semi-Analytical Model of Filtering Effects in Microwave Phase Shifters Based on Semiconductor Optical Amplifiers, *Yaohui Chen, Weiqi Xue, Filip Öhman, Jesper Mørk; DTU Fotonik, Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We present a model to interpret enhanced microwave phase shifts based on filter assisted slow and fast light effects in semiconductor optical amplifiers. The model also demonstrates the spectral phase impact of input optical signals.

JMB15
Electromagnetically-Induced-Transparency Effect in a V-Type Medium Controlled by an Incoherent Pumping Field, *Wenzhuo Tang, Luming Li, Hong Guo; Peking Univ., China.* The electromagnetically induced transparency effect in a V-type medium controlled by an incoherent pumping field is studied both experimentally and theoretically, which shows that different propagation directions have absolutely opposite effect.

JMB16
Fractional Advancement Enhancement in Erbium-Doped Fiber Amplifiers by Bi-Directional Pumping, *Jose Miguel Ezquerro, Sonia Melle, Oscar G. Calderón, Fernando Carreño, Miguel A. Antón; Univ. Complutense de Madrid, Spain.* We experimentally analyze the fractional advancement of amplitude-modulated 1550 nm signals when propagating through highly-doped erbium fibers pumped at 980 nm in different pump configurations.

JMB17
Controlling the Photonic Band Structure of Driven Color Centers in Diamond, *Jin Hui Wu[1], Giuseppe C. La Rocca[2], Maurizio Artoni[3]; [1]College of Physics, Jilin Univ., China, [2]Scuola Normale Superiore, Italy, [3]European Lab for Nonlinear Spectroscopy and Dept. of Physics and Chemistry of Materials, Brescia Univ., Italy.* Inhomogeneously broadened optical transitions of nitrogen-vacancy centers in diamond may be

employed to attain fully developed photonic band-gap structures. Reflectivities very close to unity and sufficiently large bandwidths may be observed for realistic parameters.

JMB18

Slow Higher-Order Optical Soliton in a Resonance Photonic Crystal with Self-Engineered Defect, *Igor V. Mel'nikov[1], Anton N. Knigavko[2]; [1]Optolink Ltd, Russian Federation, [2]High Q Labs, Inc, Canada.* We demonstrate previously unforeseen properties of stable propagation and trapping of a higher-order solitons of self-induced transparency which can be mediated by a superradiance decay inside the resonance photonic crystal.

JMB19

Magnetically Induced Reduction of Energy Transport Velocity in Magnetic Colloids, *Rajesh J. Patel, Bhupendra N. Chudasama, Nidhi M. Andhariya, R. V. Upadhyay, R. V. Mehta; Bhavnagar Univ., India.* Magnetically induced modulation of refractive index and Mie resonance is employed to reduce energy transport velocity of incident polarized light in magnetic colloids. At a critical field complete halt of light is observed.

JMB20

Electromagnetically Induced Transparency with a Standing Drive Field in Rubidium D2 Line, *XiaoGang Wei, Yi Chen, KiYoung Cho, ByoungSeung Ham; Inha Univ., Republic of Korea.* We studied electromagnetically induced transparency in a Rubidium D2 line with standing coupling fields and demonstrated absorption grating control for both real levels and crossover virtual levels.

JMB21

The Excitation Trapping in a Symmetrically Pumped DFB Fiber Laser with a Variable Phase Shift, *Igor V. Mel'nikov[1], Alexander V. Kir'yanov[1], M. V. Andrés[1], Anton Knigavko[2]; [1]Optolink Ltd, Russian Federation, [2]High Q Labs, Inc, Canada.* We study, both theoretically and experimentally, the generation dynamics and light trapping in a distributed feedback fiber (DFB) laser that is due to the phase shift introduced into the fiber Bragg grating structure.

JMB22

N Type Atomic System in Hot Rubidium D2 Line, *Yi Chen, XiaoGang Wei, KiYoung Cho, ByoungSeung Ham; Inha Univ., Republic of Korea.* We studied all four possible N-configuration schemes in hot Rubidium 87 D2 line, by using a second coupling field to couple the ground state of the probe field with another excited state.

JMB23

Inversion of the Coupling Absorption at the Two-Photon Resonance in a Coupling-Probe-Spectroscopy Experiment, *Katrin Dahl[1,2], Luca Spani Molella[1,2], Rolf-Hermann Rinkleff[1,2], Karsten Danzmann[1,2]; [1]Albert Einstein Inst., Max Planck Inst. für Gravitationsphysik, Germany, [2]Inst. für Gravitationsphysik, Gottfried Wilhelm Leibniz Univ. Hannover, Germany.* Using probe and coupling lasers, a system characterized by electromagnetically induced absorption was investigated. A switch of the EIA peak of the coupling laser to a dip was measured as function of the laser intensities.

JMB24

Experimental Comparison between the Index of Refraction in Strongly Driven and Degenerate Two-Level Systems, *Rolf-Hermann Rinkleff[1,2], Luca Spani Molella[1,2], Alessandra Rocco[2], Andreas Wicht[2], Karsten Danzmann[1,2]; [1]Inst. für Gravitationsphysik, Leibniz Univ., Germany, [2]Albert Einstein Inst., Max Planck Inst. für Gravitationsphysik, Germany.* Negative dispersion and transparency in a strongly driven calcium two-level system and positive dispersion and transparency or anomalous dispersion and enhanced absorption in closed degenerate two-level systems in caesium have been observed using pump-probe spectroscopy.

JMB25

Investigation of Quantum Coherent Control of Pulse Propagation in a Cold Atomic Ensemble, *Yan Xue, Byoung Seung Ham; Ctr. for Photon Information Processing, Inha Univ., Republic of Korea.* We present numerical calculations of slow light propagation through a cold atomic ensemble and discuss the followings: Bragg reflection, four-wave mixing, and temporal pulse splitting.

JMB26

Study of Fiber Ring Parameters and Their Effect on SBS Based Slow Light in Fibers, *Chung Yu[1], Christopher K. Horne[1], YongKab Kim[2]; [1]North Carolina Agricultural and Technical State Univ., USA, [2]Wonkwang Univ., Republic of Korea.* The SBS based fiber ring with orders of magnitude enhanced gain and linewidth should be an ideal candidate as a fiber slow light device. We have conducted a study with attempts for optimum slow light.

JMB27

Chirped Quantum Cascade Laser Induced Transient Gain in Strongly Absorbing Molecular Gases, *Geoffrey Duxbury, Nigel Langford, Kenneth G. Hay; Dept. of Physics, Univ. of Strathclyde, UK.* Using a mW power chirped pulse quantum cascade laser propagating in a 60 m pathlength Herriott cell, delayed rapid passage and transient gain signals have been observed in the 8 micron spectrum of acetylene.

JMB28

Subluminal and Superluminal Propagation in Er^{3+} Doped Fiber Bragg Grating, *Z. C. Zhuo, Byoung S. Ham; Inha Univ., Republic of Korea.* We present a method to achieve sublumin-al/ superluminal propagation in optical fiber Bragg grating written in Er^{3+} doped optical fiber. The group velocity with effects of modulation amplitude of the grating is discussed

JMB29

Slow Light in Distributed Feedback Laser for All-Optical Inverter, *P. C. Peng[1], F. M. Wu[1], W. J. Jiang[2], C. T. Lin[2], J. H. Chen[2], P. T. Shih[2], W. C. Kao[2], S. Chi[2,3]; [1]Natl. Chi Nan Univ., Taiwan, [2]Natl. Chiao Tung Univ., Taiwan, [3]Yuan Ze Univ., Taiwan.* This work experimentally demonstrates slow light in a distributed feedback laser for an all-optical inverter. The optical inverter operated with a binary phase-shift keying signal.

JMB30

Double Electromagnetically Induced Transparency Effect in Multi-Level Atomic Medium, *Xiao Li, Yu Liu, Bin Luo, Hong Guo; Peking Univ., China.* We report the progress in our research on the quantum coherence in multi-level atomic gases, especially the double electromagnetically induced transparency effect in four-level N-type and tripod-type atomic medium.

JMB31

Tunable Phase Control of Coherent Population Oscillations, *Francisco Arrieta-Yáñez, Oscar G. Calderón, Sonia Melle, Fernando Carreño, Miguel A. Antón; Univ. Complutense de Madrid, Spain.* We study the propagation of an amplitude modulated 1550-nm signal along an EDF pumped with an amplitude modulated 980-nm beam. A transition from super- to subluminal light depending on the phase between them is observed.

JMB32

Effect of Ion Pairs in Fast-Light Bandwidth in High-Concentration Erbium-Doped Fibers, *Oscar G. Calderón, Sonia Melle, Miguel A. Antón, Fernando Carreño; Univ. Complutense de Madrid, Spain.* The effect of ion pairs in high-concentration erbium doped fibers on slow and fast light propagation enabled by coherent population oscillations at room temperature has been experimentally investigated.

JMB33

Enhancement of Second-Order Nonlinearity and Slow-Light Generation in an Er-Doped Glass via Electromagnetically Induced Transparency, *Igor V. Mel'nikov[1], Anton N. Knigavko[2]; [1]Optolink Ltd, Russian Federation, [2]High Q Labs, Inc, Canada.* A combination of a four-level electromagnetically induced transparency and second-order nonlinearity is shown to enhance profoundly the efficiency of frequency conversion in an Er-doped glass owing to the pump-pulse slowing down.

JMB1-JMB9 can be found in the COTA abstracts.
JMB34-JMB41, JMB81 can be found in the IPNRA abstracts.
JMB42-JMB88 can be found in the ICQI abstracts.

• Tuesday, July 15 •

Atrium Foyer
7:30 a.m.–5:00 p.m.
Registration Open

JTuA • Joint Plenary Session II

Salon E
8:00 a.m.–10:00 a.m.
JTuA • Joint Plenary Session II

8:00 a.m.
Slow Light Plenary
Electro-Optic Modulation of Photons and Biphotons, *Stephen E. Harris; Stanford Univ., USA.*

8:40 a.m.
ICQI Plenary
Entanglement, Information Processing and Decoherence in Trapped Atomic Ions, *David J. Wineland; NIST, USA.*

9:20 a.m.
COTA Plenary
Coherence Cloning and Phase Controlled Apertures Using Optical Phase-Lock Loops, *Amnon Yariv; Caltech, USA.*

Salon Foyer
10:00 a.m.–10:30 a.m.
Coffee Break

STuA • Semiconductor Structures and CPO Effects

Salon G
10:30 a.m.–12:30 p.m.
STuA • Semiconductor Structures and CPO Effects
Hailin Wang; Univ. of Oregon, USA, Presider

STuA1 • 10:30 a.m. **Invited**
Slow and Fast Light in THz Regime, *Forrest G. Sedgwick; Univ. of California at Berkeley, USA.* A chirp-and-compensate scheme is employed to increase the advance-bandwidth product of 400 fs pulses in a semiconductor optical amplifier as well as to realize tunable delay, producing a record temporal shift of 10.7 pulses.

STuA2 • 11:00 a.m. **Invited**
Mid-Infrared Semiconductor Metamaterials, *Claire Gmachl; Princeton Univ., USA.* We report on a new class of 3-D, thick, broadband, n^+-InGaAs/i-AlInAs semiconductor heterostructure metamaterials that employs a strongly anisotropic dielectric function to achieve negative refraction in the mid- and long-wave infrared region of the spectrum.

STuA3 • 11:30 a.m.
Pulse-Distortion Management Using the Pulse-on-Background Method and Multiple Closely Spaced Gain Lines in Slow/Fast Light Propagation, *Heedeuk Shin, Zhimin Shi, Aaron Schweinsberg, George Gehring, Robert W. Boyd; Insitute of Optics, Univ. of Rochester, USA.* We propose using the pulse-on-background method and multiple gain lines to reduce pulse distortion in slow/fast light pulse propagation based on CPO and linear resonance system, respectively. Both methods will be described in this work.

STuA4 • 11:45 a.m.
Electrically Tunable Fast Light of 86 fs Pulses in Semiconductor Optical Amplifiers, *Bala Pesala, Forrest G. Sedgwick, Wai Son Ko, Connie Chang-Hasnain; Univ. of California at Berkeley, USA.* Large tunable advance of 6.5 pulses is achieved for an 86 fs pulse using non-linear processes in SOAs. Pulse width dependence of fast light is studied by gradually increasing the width to 1 ps.

STuA5 • 12:00 p.m.
Experimental Demonstration of Strongly Enhanced Light Slow-Down in Semiconductor Optical Amplifiers by Optical Filtering, *Weiqi Xue[1], Filip Öhman[1], Yaohui Chen[1], Salvador Sales[2], Jesper Mørk[1]; [1]Dept. of Photonics Engineering,Technical Univ. of Denmark, Denmark, [2]Inst. of Telecommunications and Multimedia Applications, Univ. Politécnica de Valencia, Spain.* Optical filtering is shown to be a powerful way of increasing light-speed control in SOAs. More than 120 degrees microwave phase shift over a bandwidth close to 15GHz is achieved.

STuA6 • 12:15 p.m.
Slow and Fast Light in Liquid Crystal Light-Valves, *Umberto Bortolozzo[1], Stefania Residori[1], Jean-Pierre Huignard[2]; [1]Inst. Non Linéaire de Nice, Univ. de Nice Sophia-Antipolis, Ctr. Natl. de la Res. Scientifique, France, [2]Thales Res. and Technology, France.* We show that fast and slow-light result from non-degenerate two-wave mixing in a liquid crystal light-valve. The large response time of the liquid crystals allows obtaining group velocities as slow as 0.13 mm/s.

12:30 p.m.–2:00 p.m.
Lunch Break

STuB • Gratings and Coupled Resonators

Salon G
2:00 p.m.–4:00 p.m.
STuB • Gratings and Coupled Resonators
Michal Lipson; Cornell Univ., USA, Presider

STuB1 • 2:00 p.m. **Invited**
Grating Induced Transparency (GIT) and the Dark Mode in Optical Waveguides, *Amnon Yariv, Hsi-Chun Liu; Caltech,*

USA. We describe a new type of propagating optical mode in a bi-perodic wavegide. It possesses a Dark Mode in formal analogy to the Dark atomic state involved in EIT. It displays transparency and slow-light behavior free from the bandwidth-delay product constraint.

STuB2 • 2:30 p.m. Invited

1 Byte Reconfigurable Integrated Optic Delay Line, *Andrea Melloni; DEI, Italy.* We experimentally demonstrated a continuously variable delay from 0 to 8bits with ps resolution with 8 coupled resonators at 10 and 25Gbit/s. The on-chip footprint is $7mm^2$ and the fractional loss is smaller than 1dB/bit.

STuB3 • 3:00 p.m.

Capturing Light Pulses Completely Using a Few Dynamic Microcavities, *Clayton R. Otey, M. L. Povinelli, Shanhui Fan; Stanford Univ., USA.* We use temporal coupled mode theory to describe a dynamic microcavity system capable of completely capturing light pulses in a pair of cavities with negligible reflection.

STuB4 • 3:15 p.m.

Phase-Disorder in Coupled-Resonator Optical Waveguides, *Carlo Ferrari, Francesco Morichetti, Andrea Melloni; Politecnico di Milano, Italy.* The effects of phase-disorder in coupled-ring-resonator optical waveguides are theoretically predicted and experimentally observed. The thermal control of the rings' resonances is exploited to measure the back-reflection of the structure for different disorder degrees.

STuB5 • 3:30 p.m.

Analysis of CROW, SCISSOR and REMZI Architectures in the Slow-Light Regime, *Vishnupriya Govindan, Steve Blair; Univ. of Utah, USA.* Under the constraint of fixed pulse distortion, REMZI architecture has the highest bandwidth-delay product compared to SCISSOR and CROW. Nonlinear response of CROW fails to improve with increasing number of resonators, but inter-pulse interaction decreases.

STuB6 • 3:45 p.m.

Control of the Group Velocity of Light in Erbium Doped Fibers Via the Modulation Frequency, *Sonia Melle, Oscar G. Calderón, Eduardo Cabrera-Granado, Miguel A. Antón, Fernando Carreño; Univ. Complutense de Madrid, Spain.* We report a change from sub- to super-luminal propagation solely upon increasing the modulation frequency of an amplitude-modulated 1550 nm signal when propagating through highly-doped erbium fibers pumped at 980 nm.

Salon Foyer
4:00 p.m.–4:30 p.m.
Coffee Break

STuC • Slow Light in Optical Fibers

Salon G
4:30 p.m.–6:30 p.m.
STuC • Slow Light in Optical Fibers
Jose Capmany; Univ. Politecnica de Valencia, Spain, Presider

STuC1 • 4:30 p.m. Invited

Slow Light Based on Stimulated Brillouin Scattering: New Possibilities and Open Questions, *Miguel Gonzalez-Herraez; Dept. of Electronics, Univ. of Alcala, Spain.* Slow light based on stimulated Brillouin scattering offers new capabilities that are unique to this interaction. These capabilities are reviewed, and the limits and potential applications of this technique are analyzed.

STuC2 • 5:00 p.m. Invited

Using Nonuniform Fiber to Generate Slow Light via Stimulated Brillouin Scattering, *Xiaoyi Bao; Univ. of Ottawa, Canada.* The pulse delay based on stimulated Brillouin scattering in a nonuniform dispersion decreasing fiber (DDF) is demonstrated. The pulse delay of more than one bit with small distortion is observed for 2ns pulse using DDF.

STuC3 • 5:30 p.m.

Observation of Large 8-Gb/s SBS Slow Light Delay with Low Distortion Using an Optimized Gain Profile, *Eduardo Cabrera Granado[1], Daniel J. Gauthier[1], Oscar G. Calderón[2], Sonia Melle[2]; [1]Duke Univ., USA, [2]Escuela Univ. de Óptica, Spain.* We obtain over 3 pulse widths SBS slow light delay for an input pulse width of 125 ps. By optimizing the gain profile, the output-to-input pulse width ratio is less than 2.

STuC4 • 5:45 p.m.

Delay Limits of SBS Based Slow Light, *Thomas Schneider, Ronny Henker, Kai-Uwe Lauterbach, Markus Junker; Hochschule für Telekommunikation, Leipzig, Germany.* We discuss the maximum time delay of slow light systems. As we will show, the maximum time delay can be enhanced from 2 to around 10 times if a gain is superimposed with two losses.

STuC5 • 6:00 p.m.

Self-Pumped Optical Delay Line Based on Brillouin Fast Light in Optical Fibers, *Luc Thevenaz, Sanghoon Chin; EPFL Swiss Federal Inst. of Technology, Switzerland.* An extremely simple technique is demonstrated to realize tunable delays in optical fibers controlled by the signal average power. The system self-adapts in real time to the Brillouin fiber properties and to the signal bandwidth.

STuC6 • 6:15 p.m.

Slow Light in Spun Fiber Optical Parametric Amplification, *Marco Santagiustina, Luca Schenato, Carlo G. Someda; Dept. of Information Engineering, Univ. of Padova, Italy.* The random birefringence mitigation effect in spun fibers is theoretically and numerically studied for slow and fast light applications in narrow band optical parametric amplification. Enhanced performances are demonstrated and explained.

Salon F
6:30 p.m.–8:00 p.m.
Conference Reception

NOTES

• Wednesday, July 16 •

Atrium Foyer
7:30 a.m.–5:00 p.m.
Registration Open

SWA • Fundamental Limitations and New Applications

Salon G
8:00 a.m.–10:00 a.m.
SWA • Fundamental Limitations and New Applications
Shun L. Chuang; Univ. of Illinois, USA, Presider

SWA1 • 8:00 a.m. **Invited**
Loss, Noise, Power Dissipation: How They Affect Performance of Slow Light Devices, *Jacob B. Khurgin; Johns Hopkins Univ., USA.* Performance of diverse slow light schemes is analyzed from the vantage point of signal to noise ratio, dynamic range, and power dissipation. Applications that can be most positively affected by using slow light are identified.

SWA2 • 8:30 a.m. **Invited**
Fundamental Limits in Linear One-Dimensional Slow Light Structures, *David A. B. Miller; Stanford Univ., USA.* An upper limit can be deduced for the number of bits of delay, depending only on the materials used and independent of detailed design. The proof and applications of this limit will be discussed.

SWA3 • 9:00 a.m.
Enhancement of the Spectral Performance of Interferometers Using Slow Light under Practical Conditions, *Zhimin Shi, Robert W. Boyd; Inst. of Optics, Univ. of Rochester, USA.* We investigate how slow light can enhance the performance of various types of spectroscopic interferometers, and how the performance is influenced by the associated gain/absorption and by the group index dispersion of the slow-light medium.

SWA4 • 9:15 a.m.
Superluminal Pulse Propagation on a Silicon Chip, *Sasikanth Manipatruni, Po Dong, Qianfan Xu, Michal Lipson; Cornell Univ., USA.* We demonstrate superluminal pulse propagation on a silicon chip using an all-optical analog to electromagnetically induced absorption created by the coherent interaction between two micro-resonators. We show group indices tunable between -1158 and -312.

SWA5 • 9:30 a.m.
Information Theoretic Analysis of a Slow-Light Channel, *Mark A. Neifeld, Myungjun Lee; Univ. of Arizona, USA.* We present a new formalism for the analysis of a slow-light channel, which enables natural information-theoretic definitions for delay and capacity. We apply this formalism to a simple gain-based delay system.

SWA6 • 9:45 a.m.
Controlling Light Propagation via Radiation Pressure and Optomechanical Coupling, *Olivier Arcizet, Albert Schliesser, Tobias J. Kippenberg; Max Planck Inst. for Quantum Optics, Germany.* We experimentally demonstrate for the first time the possibility of controlling the propagation properties of a light pulse using cavity assisted radiation pressure coupling to mechanical modes. Both pulse delay and advancement are experimentally demonstrated.

Salon Foyer
10:00 a.m.–10:30 a.m.
Coffee Break

SWB • Metamaterials and Photonic Crystals

Salon G
10:30 a.m.–12:30 p.m.
SWB • Metamaterials and Photonic Crystals
Luc Thevenaz; EPFL Swiss Federal Inst. of Technology, Switzerland, Presider

SWB1 • 10:30 a.m. **Invited**
Broad Bandwidth Slow Light, Enabled by Surface Plasmons and Polaritons, *Marin Soljacic; MIT, USA.* We discuss a few different slow light systems, enabled by polaritons and surface plasmons: slow light in resonant photonic crystals, and small modal area surface plasmon waveguides, with low group velocities over unusually large bandwidths.

SWB2 • 11:00 a.m. **Invited**
Slow Light in Photonic-Crystal Waveguides and Cavities, *Solomon Assefa, Fengnian Xia, William M. J. Green, Yurii Vlasov; IBM TJ Watson Res. Ctr., USA.* Coupling losses and high-order dispersion in the slow-light regime of photonic-crystal (PhC) waveguides are investigated by utilizing an integrated Mach-Zehnder interferometer. Furthermore, PhC cavities coupled to photonic-wires through surface-states are experimentally characterized.

SWB3 • 11:30 a.m.
Enhanced Slow Light in Quantum Dot Photonic Crystal Waveguides, *Torben R. Nielsen, Andrei Lavrinenko, Jesper Mørk; Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We present a theoretical analysis of pulse propagation in a quantum dot semiconductor photonic crystal waveguide in the regime of electromagnetically induced transparency. The slow-down factor for the combined system is determined.

SWB4 • 11:45 a.m.
Negative Group Velocity: Is It a Negative Index Material or

Fast Light? *Eyal Feigenbaum, Noam Kaminski, Meir Orenstein; Technion, Israel.* When negative slop of the dispersion curve is encountered, the propagating light may be either "fast light" or "backward propagating." We show that the same photonic (plasmonic) system can support both these disjoint solutions.

SWB5 • 12:00 p.m.
Energy Velocity in Negative Group Index Structures, *Weiguo Yang[1], John O. Schenk[2], Michael A. Fiddy[2]; [1]Western Carolina Univ., USA, [2]Univ. of North Carolina at Charlotte, USA.* Energy velocity in negative group index structures is investigated. It is shown that the negative group index phenomenon is an exhibition of effective negative index-of-refraction while the group velocity still equals the energy velocity.

SWB6 • 12:15 p.m.
Lossless Negative Refraction in an Active Gas of Atoms, *Jörg Evers, Peter P. Orth, Christoph H. Keitel; Max-Planck-Inst. für Kernphysik, Germany.* Lossless negative refraction in an active dense gas of atoms is predicted. A weak incoherent pumping field renders the gas active, enabling a qualitatively new parameter range not accessible with current devices.

12:30 p.m.–2:00 p.m.
Lunch Break

SWC •Photonic Crystals

Salon G
2:00 p.m.–4:00 p.m.
SWC •Photonic Crystals
Marin Soljacic; MIT, USA, Presider

SWC1 • 2:00 p.m. **Invited**
Slow Light Media Based on Ultrahigh-*Q* Nanocavities, *Masaya Notomi, T. Tanabe, E. Kuramochi, H. Taniyama; NTT Basic Res. Labs, Japan.* In this study, we apply ultrahigh-*Q* (>1 million) nanocavities in silicon photonic crystals for slowlight application. We have observed the group velocity down to c/50,000 and succeeded in cascading N>100 ultrahigh-Q cavities in series.

SWC2 • 2:30 p.m. **Invited**
Impact of Nonlinearity and Disorder on Slow Modes in Membrane Photonic Crystals, *Alfredo Rossi; Thales Res. and Technology, France.* Disorder induced scattering is crucial for understanding slow light in Photonic Crystal. We investigate dispersion and scattering losses on PhC structures with tailored dispersion and discuss their potential for delay control and all-optical switching.

SWC3 • 3:00 p.m.
100 Gbit/s / 1 V Optical Modulator with Slotted Slow-Light Polymer-Infiltrated Silicon Photonic Crystal, *Jan M. Brosi[1], Christian Koos[1], Lucio C. Andreani[2], Pieter Dumon[3], Roel Baets[3], Juerg Leuthold[1], Wolfgang Freude[1]; [1]Inst. of High-Frequency and Quantum Electronics, Univ. of Karlsruhe, Germany, [2]Dept. of Physics "A. Volta", Univ. of Pavia, Italy, [3]Ghent Univ., Belgium.* An optical modulator with 78 GHz bandwidth, 1 V drive voltage and 80 μm length is proposed, allowing 100 Gbit/s transmission. Design, modulator performance parameters and measurements of the slow-light photonic crystal waveguide are discussed.

SWC4 • 3:15 p.m.
Systematic Design of Broadband Slow Light Photonic Crystal Waveguides, *Thomas P. White[1], Juntao Li[2], Liam O'Faolain[1], Thomas F. Krauss[1]; [1]Univ. of St. Andrews, UK, [2]Sun Yat-sen Univ., China.* We present a systematic design approach for broadband slow light photonic crystal waveguides. Precise control of group velocities between c/30 and c/90 is possible while maintaining an almost constant group index-bandwidth product.

SWC5 • 3:30 p.m.
Slow-Light Enhanced Second Harmonic Generation in a Two-Dimensional Photonic Crystal, *Rumen Iliew[1], Christoph Etrich[2], Thomas Pertsch[2], Falk Lederer[1]; [1]Inst. für Festkörpertheorie und -optik, Friedrich-Schiller-Univ. Jena, Germany, [2]Inst. für Angewandte Physik/ultra optics, Friedrich-Schiller-Univ. Jena, Germany.* We obtain greatly enhanced conversion efficiencies of second harmonic generation by achieving small group velocity at phasematch in a two-dimensional quadratically nonlinear photonic crystal. The theoretically proposed efficiency is confirmed with rigorous finite-difference time-domain calculations.

SWC6 • 3:45 p.m.
Revisiting Photon Tunneling through Finite 1-D Dielectric Photonic Crystals, *Daniel R. Solli[1], James J. Morehead[2], Colin F. McCormick[3], Jandir M. Hickmann[4]; [1]Univ. of California at Los Angeles, USA, [2]JDSU, USA, [3]U.S. House of Representatives Committee on Science and Technology, USA, [4]Optics and Materials Group, Optma Inst. de Física, Univ. Federal de Alagoas, Brazil.* We re-examine the propagation of light in the band gaps of 1-D dielectric photonic crystals comparing with the evanescent solutions of matter waves in classically forbidden potentials and determining similarities and differences.

Salon Foyer
4:00 p.m.–4:30 p.m.
Coffee Break

SWD • Slow Light in Atomic Vapors

Salon G
4:30 p.m.–6:30 p.m.
SWD • Slow Light in Atomic Vapors
Daniel Gauthier; Duke Univ., USA, Presider

SWD1 • 4:30 p.m. **Invited**
Ultralong Tunable Delays, *Alexander Gaeta; Cornell Univ., USA.* We describe review our recent work on all-optical techniques for producing tunable delays as large as 100 ns in optical waveguides.

SWD2 • 5:00 p.m.
Diffusion of Slow-Light in Thermal Vapor, *Ofer Firstenberg[1], Moshe Shuker[1], Rami Pugatch[2], Donald R. Fredkin[3], Nir Davidson[2], Amiram Ron[1]; [1]Dept. of Physics, Technion-Israel Inst. of Technology, Israel, [2]Dept. of Physics of Complex Systems, Weizmann Inst. of Science, Israel, [3]Dept. of Physics, Univ. of California, USA.* We study the effect of thermal motion on slow-light with electromagnetically-induced transparency. By incorporating the atomic motion into the Maxwell-Bloch equations, we find a transmission filter that leads to diffusion-like behavior of the field's envelope.

SWD3 • 5:15 p.m.
Slowing and Storing Images in Atomic Vapor, *Moshe Shuker[1], Ofer Firstenberg[1], Rami Pugatch[2], Amiram Ron[1], Nir Davidson[2]; [1]Technion-Israel Inst. of Technology, Israel, [2]Weizmann Inst. of Science, Israel.* We study slowing and storage of three-dimensional light fields in atomic vapor. We demonstrate a technique which reduces the effect of diffusion on the storage fidelity and prove that the phase pattern was also maintained.

SWD4 • 5:30 p.m.
Storage and Retrieval of Images in Hot Atomic Rubidium Vapor, *Praveen K. Vudyasetu, Ryan M. Camacho, John C. Howell; Univ. of Rochester, USA.* We demonstrate four wave mixing and electromagnetically induced transparency mediated storage of multimode transverse images carried by optical pulses in hot atomic Rubidium vapor and show that the images retrieved are robust to diffusion.

SWD5 • 5:45 p.m.
Four Wave Mixing Based Stopped Light in Optically Thick Hot Rubidium Vapor, *Ryan M. Camacho, Praveen K. Vudyasetu, John C. Howell; Univ. of Rochester, USA.* We discuss stored light in warm Rubidium vapor. Mediated by FWM, the idler pulses are spontaneously generated in the medium, and then stored and retrieved simultaneously with the signal pulses.

NOTES

Key to Authors and Presiders

(**Bold** denotes Presider or Presenting Author)

2008 OSA Summer Optics & Photonics Congress Update Sheet and Addendum

Additional Authors

CMA2 — *Paul W. Juodawlkis[1], Jason L. Plant[1], Fred J. O'Donnell[1], Leo J. Missaggia[1], Robin K. Huang[1], Joseph P. Donnelly[1], John B. Schlager[2], William Swann[2], Nathan R. Newbury[2], Sangyoun Gee[3], Sarper Ozharar[3], Franklyn Quinlan[3], Peter J. Delfyett[3]; [1]MIT Lincoln Lab, USA, [2]Natl. Inst. of Standards and Technology, USA, [3]CREOL, Univ. of Central Florida, USA.*

SWC2 — *Alfredo Rossi[1], S. Combrié[1], Q. V. Tran[1], C. Husko[1], G. Vadalà[1], P. Hamel[2], R. Gabet[2], Y. Jaouën[2], A. Parini[3], Y. Gottesman[3], F. Raineri[4]; [1]Thales Res. and Technology, France, [2]GET/Telecom Paris, France, [3]Inst. Natl. des Télécommunications, France, [4]Lab de Photonique et de Nanostructures, France.*

JMB1 — This poster will be presented by *Irakli Chaganava; Georgian Technical Univ., Georgia.*

Updated Titles

CWB1 — **Compensation of Chromatic Dispersion and Nonlinearity Using Simplified Digital Backpropagation**
CWC1 — **Real-Time 46 Gb/s Coherent System**
IMC7 — **Dispersion Engineering in Silicon Photonic Wires Using Thin Si_3N_4 Conformal Dielectric Coating**
QMA2 — **Decoherence and Entanglement for Quantum Critical Baths**
QWD2 — **Electromagnetically-Induced Transparency and Squeezed Light**
QWD3 — **Qubus Computation and Its Applications to Hybrid Quantum Repeaters**
STuA1 — **Novel Chirp and Compensate Scheme to Enhance Fast Light in a Semiconductor Optical Amplifier**
STuA2 — **Negative Refraction in a Semiconductor Metamaterial in the Mid-Infrared**
JMB35 — **Chirped Multilayer Mirror Based on Silicon Nitride (Si_3N_4) with Air-Gap Interlayers**
JMB67 — **Simulation of the Quantum Decoherence Effect for $^{79}Br^{85}Rb$**

Updated Papers

CTuA6 • 12:30 p.m.–1:00 p.m. (Invited)
Quantitative Phase Imaging of Cells and Tissues, *Gabriel Popescu; MIT, USA.* We developed novel imaging techniques for quantifying optical phase shifts produced by cells and tissues with unprecedented accuracy. This approach provides information about structure and dynamics at the nanometer and millisecond scales, with broad range of biomedical applications, including cell membrane dynamics, cell growth, and tissue diagnosis.

CWA5 • 9:45 a.m.
Optical Interconnects for Petaflops Supercomputers, *Hirsch Mandelberg; Lab for Physical Sciences, Univ. of Maryland, USA.* We discuss the requirements for an optical interconnect system capable of providing the multi-petabit/sec bandwidth, operating in a cryogenic-to-room-temperature environment, necessary for a petaflops supercomputer based on Josephson junction processors and memory.

A full summary of paper CWA is attached.

Updated Presiders

CTuB — *Yu Chen; Univ. of Maryland, USA.*

New Presiders to be announced on-site: CMB, CMC, CWB, CWC, IMB, ITuC, IWA, IWD, QMB, SMB, STuA, STuC

Withdrawals

QMA2, SMA5, JMB53, JMB75

Optical Interconnects for Petaflops Supercomputers

Hirsch I. Mandelberg
Laboratory for Physical Sciences, 8050 Greenmead Drive, College Park, MD20740
hirsch@lps.umd.edu)

Abstract: A new program has been initiated for the development of the technologies necessary to construct a petaflops supercomputer based on Josephson junction processors and memory. The requirements for an optical interconnect system capable of providing the necessary multi-petabit/sec bandwidth, operating in a cryogenic-to-room-temperature environment, will be discussed, along with some of the options being considered.

1. Superconducting Technology Assessment

The challenges to extending the delivered computing capabilities of semiconductor technology through Moore's Law, while manageable in the short term, may prove difficult or possibly impractical in the long term. Even now, the complex interplay of power and performance is resulting in significant changes in previous trends. Clock rates of commodity microprocessors are flattening even as multi-core chips are emerging as the norm for next generation systems. While conventional wisdom has dictated an assumption of continued adherence to the pure CMOS tradition of the last decade and more, the supercomputing community must consider the possibility of alternative technologies, at least in combination with more conventional devices. New architecture structures and programming models may also need to be considered to exploit the potential of such advances.

A panel of superconducting experts was challenged by the National Security Agency to do an independent assessment of the future of Rapid Single Flux Quantum (RSFQ) superconductor circuits to address the 2010-2015 petaflops system challenges of the high end user community. RSFQ logic exhibits operational properties in terms of performance and power that now positions it as a potential future leader among alternative digital technologies to augment semiconductor components in hybrid systems. But it is also challenged by lack of maturity and commercial market as well as its reliance on extreme operational temperature regimes. RSFQ technology may deliver clock rates in excess of an order of magnitude greater than that of the corresponding semiconductor logic and with dramatically reduced power requirements. Nonetheless, in spite of decades of research and experience with small fabrication lines, it has not managed to challenge the prevailing semiconductor technologies. However, the increasing difficulties to sustaining current level of growth in density and performance of CMOS within practical power constraints may change this. Critical issues of technology and architecture and how RSFQ may contribute effectively to future supercomputing next decade were considered. Six major areas were addressed: 1) superconductor technology, 2) micro-architecture using RSFQ, 3) hybrid memory systems, 4) system architecture incorporating superconductor components, 5) interconnects and system input/output and 6) system integration. The results of this study were reported at Supercomputing 2005 [1], and are available online [2].

2. Optical Input/Output Requirements

In petaflops-scale computer systems, the processor to memory and processor to processor data rates are enormous; the estimated bidirectional bandwidth requirement is 32 Petabits/s. The use of RSFQ digital circuits with clock frequencies exceeding 50 GHz imposes challenges resulting from the increasing differential between memory cycle time and processor clock. Reduced time-of-flight (TOF) latency motivates the use of cryogenic memory close to the processor. Providing the required bandwidth between room-temperature electronics and the cryogenic RSFQ processor elements requires careful engineering of the balance between the thermal load on the cryogenics and the number, type, bandwidth, and active elements of the lines providing input/output (I/O). The major interconnection, data communication, and I/O needs of a petaflops-scale system based on cryogenic RSFQ technology are: 1) high throughput data input to the cryogenic processors and/or memory at 4 K, 2) high throughput output from the 4 K operating regime to room-temperature system elements such as secondary and archival storage, and 3) communication between processor elements within the 4 K processing system at data rates commensurate with the processor clock rate.

While RSFQ processors allow construction of a compact (~1 m^3) processing unit, a superconductor petaflops-scale computer is a very large machine, on the scale of tens of meters, with high data bandwidth requirements. For example, a particular architecture may require more than half a million data streams at 50 Gbps each between the superconductor processors and room-temperature memory. One potential solution is to use optical interconnect technologies.

The main issue to be dealt with is the electrical power requirement for communicating from the 4K environment to room temperature considering the currently achievable refrigeration efficiency of 0.1%. For example, using a figure of 3mW/GHz achieved using VCSELS [3] would require 30 kW in the cryogenic environment, or 30 MW of power if the VCSELs were at 4K. This does not include power for interface amplifiers to go from RSFQ circuit output voltages of 5 mV to that needed to drive the VCSELs. This compares to 4 MW for the entire RSFQ processor. This power level arises from 4096 separate processors each dissipating about 1 watt at 4K. One envisioned solution to this is to generate the photons at room temperature, and modulate them at an intermediate temperature (30K-40K) with a refrigeration efficiency of 2%, which is electrically connected to the 4K processor. This is shown in Figure 1.

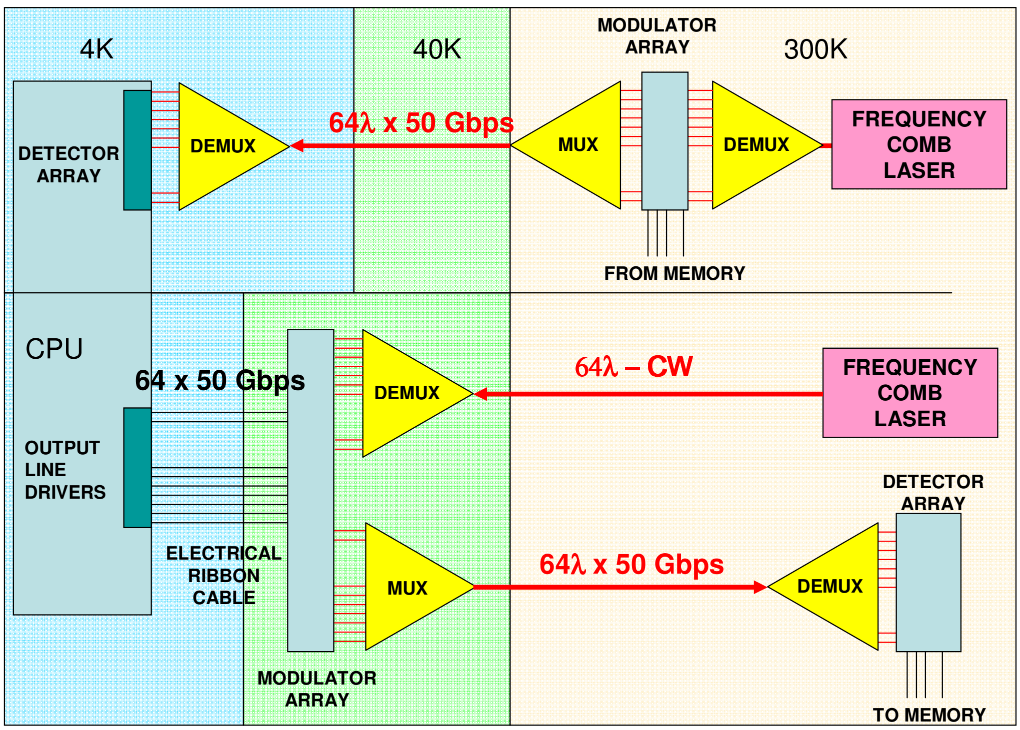


Figure 1: A 3 fiber, 64 wavelength, 50 Gbps DWDM System for bidirectional transmission totaling 6.4 Tbps between each of 4096 superconductor processors at 4K and mass memory at 300K**.**

Low power can be achieved in a number of ways. One is to reduce the voltage levels required to drive the low temperature operation modulators. Another is to use high order modulation techniques to reduce the operating frequency of each modulator, and thereby the drive voltage required. While this increases the number of modulators, it improves the spectral efficiency, and reduces the overall power. This also opens other options, which will be discussed. It should be noted that with the short distances involved, transmission impairments are not an issue and coherent optical receivers are greatly simplified.

3. References

[1] T. Sterling, M. Dorojevets, B. Smith, T. Van Duzer, A. Silver "Superconducting Technology Assessment Panel Session", Super Computers 2005, Seattle, WA, November 12-18, 2005

[2] www.nitrd.gov/pubs/nsa/sta.pdf

[3] C. Kromer, G. Sialm, C. Berger, T. Morf, M.L. Schmatz, F. Ellinger, D. Erni, G-L Bona, H. Jackel, "A 100 mW 4/spl times/10Gb/s transceiver in 80-nm CMOS for high density optical interconnects", IEEE Journal of Solid State Circuits, **23**, 2667-2679 (2005).