Quantum Entanglement and Decoherence: 3rd International Conference on Quantum Information (ICQI)

Topical Meeting and Tabletop Exhibit

Collocated with:
Slow and Fast Light (SL)
Coherent Optical Technologies and Applications (COTA)
Integrated Photonics and Nanophotonics Research and Applications (IPNRA)

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

General Chairs
Janos Bergou, *CUNY Hunter College, USA*
Bahaa Saleh, *Boston Univ., USA*

Program Chairs
Saverio Pascazio, *Univ. di Bari, Italy*
Aephraim Steinberg, *Univ. of Toronto, Canada*

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 ICQI 2007 highlights.

About ICQI

July 13-16, 2008

The 3rd International Conference on Quantum Information will be held July 13-16 in Boston Marriott Copley Place, Boston, Massachusetts, collocated with the OSA Summer Congress, a cluster of four topical meetings. The other three meetings are Slow and Fast Light (SL), Integrated Photonics and Nanophotonics Research and Applications (IPNRA), and Coherent Optical Technologies and Applications (COTA).

Quantum information is an exciting, rapidly growing area of scientific interest and development, attracting cutting edge theoretical and experimental research worldwide.

Entanglement is a key resource, decoherence is the main adversary for quantum information and quantum computing while optical methods play a key role in many implementations of quantum information. The meeting will concentrate on these three areas but contributions from all areas of quantum information are welcome.

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

Quantum Entanglement and Decoherence: 3rd International Conference on Quantum Information (ICQI) Meeting Topics

Topics to be covered include:

- 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

ICQI Technical Program Committee

General Chairs

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Bahaa Saleh, *Boston Univ., USA*

Program Chairs

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Aephraim Steinberg, *Univ. of Toronto, Canada*

Program Committee

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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

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COTA

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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.

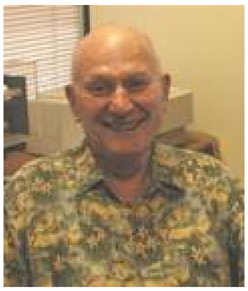
Dr. Krishnamoorthy serves on the technical advisory board for several optical technology start-ups and venture funds, and as a distinguished lecturer for IEEE/LEOS. He holds 40 patents and has contributed 150 technical publications, five book chapters and presented over 45 invited talks at international 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*

ICQI Plenary and Invited Speakers

Plenary Speaker:

Entanglement, Information Processing and Decoherence in Trapped Atomic Ions, *David Wineland;* NIST, USA

Photonic Entanglement in Quantum Communication and Quantum Computation, Anton Zeilinger, *Univ. of Vienna, Austria*

Invited Speakers:

QMA1, **Purity and Entanglement of Two-Photon States Generated by Parametric Down-Conversion,** *Carlos H. Monken; Univ. Federal de Minas Gerais, Brazil.*

QMA3, **Control of Superposition States of Continuous Variables by Photon Counting and Filtering with cw Squeezed Light,** *Masahide Sasaki; Natl. Inst. of Information and Communications Technology, Japan.*

QMB1, **Engineering Multiparameter Entangled State with Adaptive Optics,** *Alexander V. Sergienko[1], Cristian Bonato[2], Stefano Bonora[2], Paolo Villoresi[2]; [1]Dept. of ECE, Boston Univ., USA, [2]CNR-INFM LUXOR, Dept. of Information Engineering, Univ. of Padova, Italy.*

QMB2, **Revealing Anyonic Statistics with Multiphoton Entanglement,** *W. Wieczorek[1,2], Ch. Schmid[1,2], N. Kiesel[1,2], R. Pohlner[1,2], J. Pachos[3], Harald Weinfurter[1,2]; [1]Max-Planck-Inst. of Quantum Optics, Germany, [2]Dept. of Physics, Ludwig-Maximilians-Univ. Munich, Germany, [3]School of Physics and Astronomy, Univ. of Leeds, United Kingdom.*

QMB3, **Percolation Theory, Optical Quantum Computing, and Computational Phases of Matter ,** *Terry G. Rudolph; Imperial College, United Kingdom.*

QMC1, **Polar Molecules and Circuit QED: Towards Hybrid Quantum Computing,** *Peter Rabl[1,2], David DeMille[3], John M. Doyle[2], Mikhail D. Lukin[1,2], Robert J. Schoelkopf[4], Peter Zoller[5]; [1]Inst. for Theoretical Atomic, Molecular and Optical Physics, USA, [2]Physics Dept., Harvard Univ., USA, [3]Dept. of Physics, Yale Univ., USA, [4]Dept. of Applied Physics, Yale Univ., USA, [5]Inst. for Theoretical Physics, Univ. of Innsbruck, Austria.*

QTuA1, **The Quantum Cost of a Nonlocal Measurement,** *Somshubhro Bandyopadhyay[1], Shelby Kimmel[2], William K. Wootters[2]; [1]Univ. de Montéal, Canada, [2]Williams College, USA.*

QTuA2, **Phase Transitions in the Statistics of Bipartite Entanglement,** *Antonello Scardicchio; Princeton Univ., USA.*

QTuA3, **Single Atom - Single Photon Interfaces,** *F. Rohde, C. Schuck, M. Hennrich, M. Almendros, A. Haase, N. Piro, F. Dubin, M. Mitchell, R. Gehr, Juergen Eschner; ICFO - Inst. of Photonic Sciences, Spain.*

QTuB1, **The Physics of Ghost Imaging,** *Yanhua Shih; Univ. of Maryland, Baltimore County, USA.*

QTuC1, **Non-Markov Control of Quantum Thermodynamics in Multipartite Systems,** *Gershon Kurizki; Dept. of Chemical Physics, Weizmann Inst. of Science, Israel.*

QTuC3, **Factorization of Numbers and Gauss Sums,** *Wolfgang Schleich; Dept. of Quantum Physics, Univ. of Ulm, Germany.*

QTuC4, **Quantum Walks--Types and Properties,** *Igor Jex[1], Martin Stefanak[1], Tamas Kiss[2]; [1]Czech Technical Univ., Czech Republic, [2]RISPO Hungarian Acad. of Sciences, Hungary.*

QWA1, **A Universal Set of Quantum Gates on Trapped Ions in a Decoherence-Free Subspace,** *Hartmut Häffner; Inst. für Quantenoptik und Quanteninformation, Austria.*

QWA2, **Probing Quantum Rules with Single-Photon Creation and Annihilation Operators,** *Marco Bellini; Inst. Nazionale di Ottica Applicata and LENS/Univ. of Florence, Italy.*

QWA3, **One-Way Quantum Computation with Two-Photon Multiqubit Cluster States,** *Paolo Mataloni; Univ. degli Studi di Roma, Italy.*

QWB1, **Tomography for Quantum Diagnostics,** *Zdenek Hradil[1], Jaroslav Rehacek[1], Dmitri Mogilevtsev[2]; [1]Palacky Univ. Olomouc, Czech Republic, [2]Inst. of Physics, Belarus.*

QWC1, **An Exponential Separation between the Entanglement and Communication Capacities of a Bipartite Unitary Interaction,** *Debbie Leung; Univ. of Waterloo, Canada.*

QWC2, **Unambiguous Preparation of Non-Orthogonal Quantum States,** *Fabian Torres-Ruiz[1], José Aguirre[1], Aldo Delgado[1], G. Lima[1], Sebastiao Pádua[1,2], Luis Roa[1], Carlos Saavedra[1]; [1]Dept. de Física, Univ. de Concepción, Chile, [2]Dept. de Física, Univ. Federal de Minas Gerais, Brazil.*

QWD1, **Partial Measurement Based Quantum Operations,** *Gerd Leuchs; Inst. für Optik, Information und Photonik, Germany.*

QWD2, **Electromagnetically-Induced Transparency with Squeezed Light,** *Alexander Lvovsky; Univ. of Calgary, Canada.*

QWD3, **Quantum Computing and Its Applications to Hybrid Quantum Repeaters,** *Kae Nemoto; Natl. Inst. of Informatics, Japan.*

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

Quantum Entanglement and Decoherence: 3rd International Conference on Quantum Information (ICQI)

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

QMA • Entanglement I

Salons H–J
10:30 a.m.–12:30 p.m.
QMA • Entanglement I
Bahaa Saleh; Boston Univ., USA, Presider

QMA1 • 10:30 a.m. **Invited**
Purity and Entanglement of Two-Photon States Generated by Parametric Down-Conversion, *Carlos H. Monken; Univ. Federal de Minas Gerais, Brazil.* We elucidate the dependence of purity and entanglement of two-photon states generated by parametric down-conversion on the parameters of the source, such as crystal length, pump beam spatial bandwidth and detectors angular apertures.

QMA2 • 11:00 a.m. **Invited**
Decoherence and Entanglement for Quantum Critical Baths, *Rosario Fazio; Intl. School for Advanced Studies (SISSA), Italy.* I introduce, and determine decoherence for, a wide class of non-trivial quantum critical baths coupled to a two-level system. I will describe the properties of decoherence and its relations with the entanglement in the bath.

QMA3 • 11:30 a.m. **Invited**
Control of Superposition States of Continuous Variables by Photon Counting and Filtering with cw Squeezed Light, *Masahide Sasaki; Natl. Inst. of Information and Communications Technology, Japan.* The two-photon subtraction from overlapping squeezed packets generates temporally multiplexed superposition states of continuous variables with a designated time separation. In an appropriate mode an amplified superposition state is produced due to bosonic quantum interference.

QMA4 • 12:00 p.m.
Entangled State Engineering in Single-Mode Fibers, *Joseph B. Altepeter, Jun Chen, Prem Kumar; Northwestern Univ., USA.* We present novel designs for fiber-based sources of entangled photon pairs, and investigate the increasing number of available options for quantum-state engineering in the telecom band using four-wave mixing in standard fibers.

QMA5 • 12:15 p.m.
Experimental Generation of Frequency-Degenerate Bright EPR Beams with a Self-Locked Optical Parametric Oscillator, *Virginia D'Auria[1], Gaelle Keller[1], Nicolas Treps[1], Thomas Coudreau[2], Julien Laurat[1], Claude Fabre[1]; [1]Lab Kastler Brossel, Univ. Pierre et Marie Curie, Ecole Normale Superiéure, CNRS, France, [2]Lab Matériaux et Phénomènes Quantiques, Univ. Denis Diderot, Lab Kastler Brossel, Univ. Pierre et Marie Curie, Ecole Normale Superiéure, CNRS, France.* We report the first experimental generation of bright frequency-degenerate EPR-beams with a type-II OPO. Degeneracy is obtained by introducing a birefringent plate inside the cavity, resulting in phase locking. EPR-correlation is characterized by homodyne detection.

12:30 p.m.–2:00 p.m.
Lunch Break

QMB • Entanglement II

Salons H–J
2:00 p.m.–4:00 p.m.
QMB • Entanglement II
Rosario Fazio; Intl. School for Advanced Studies (SISSA), Italy, Presider

QMB1 • 2:00 p.m. **Invited**
Engineering Multiparameter Entangled State with Adaptive Optics, *Alexander V. Sergienko[1], Cristian Bonato[2], Stefano Bonora[2], Paolo Villoresi[2]; [1]Dept. of ECE, Boston Univ., USA, [2]CNR-INFM LUXOR, Dept. of Information Engineering, Univ. of Padova, Italy.* We discuss the possibility of actively manipulating entangled states generated by type-II parametric down conversion. We study what effect active manipulation of wavevector using adaptive mirror will have on the behavior of polarization-temporal interference.

QMB2 • 2:30 p.m. **Invited**
Revealing Anyonic Statistics with Multiphoton Entanglement, *W. Wieczorek[1,2], Ch. Schmid[1,2], N. Kiesel[1,2], R. Pohlner[1,2], J. Pachos[3], Harald Weinfurter[1,2]; [1]Max-Planck-Inst. of Quantum Optics, Germany, [2]Dept. of Physics, Ludwig-Maximilians-Univ. Munich, Germany, [3]School of Physics and Astronomy, Univ. of Leeds, UK.* Anyons, manifested as quasiparticles in two-dimensional systems, exhibit fractional statistics that ranges continuously from bosonic to fermionic behavior. Here, we reveal anyonic features in a quantum simulation using multi-partite entangled state of polarized photons.

QMB3 • 3:00 p.m. **Invited**
Percolation Theory, Optical Quantum Computing, and Computational Phases of Matter, *Terry G. Rudolph; Imperial College, UK.* I review two results: robust methods for ballistic linear optical quantum computing, and phases of matter defined by their quantum computational universality, which make use of percolation theory–a fascinating phenomenon of classical statistical mechanics.

QMB4 • 3:30 p.m.
Long-Distance Entanglement between a Photon and a Single Trapped Atom, *Wenjamin Rosenfeld[1], Fredrik Hocke[1], Florian Henkel[1], Michael Krug[1], Andreas Deeg[1], Christian Jakob[1], Jürgen Volz[2], Markus Weber[1], Harald Weinfurter[1]; [1]Fakultat für Physik, Ludwig-Maximilians Univ. München, Germany, [2]Lab Kastler Brossel de l'ENS, France.* Atom-photon entanglement provides a powerful interface between atomic memories and photonic communication channels. As a first step towards long-distance quantum communication we demonstrate atom-photon entanglement over a 300 m long optical fiber.

QMB5 • 3:45 p.m.
Angular Dimensionality of Two-Photon Entanglement, *Eric R. Eliel, Bart-Jan Pors, Suman S. R. Oemrawsigh, Martin P. van Exter, Andrea Aiello, Gert W. 't Hooft, J. P. Woerdman; Leiden Univ., Netherlands.* We use rotatable angular phase plates to determine the angular dimensionality in twin-photon entanglement. We measure values between 2 and 6, depending on the shape of the phase plates; a value of 50 seems feasible.

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

QMC • Optical and Other Implementations I

Salons H–J
4:30 p.m.–6:30 p.m.
QMC • Optical and Other Implementations I
Alexander Sergienko; Boston Univ., USA, Presider

QMC1 • 4:30 p.m. **Invited**
Polar Molecules and Circuit QED: Towards Hybrid Quantum Computing, *Peter Rabl[1,2], David DeMille[3], John M. Doyle[2], Mikhail D. Lukin[1,2], Robert J. Schoelkopf[4], Peter Zoller[5]; [1]Inst. for Theoretical Atomic, Molecular and Optical Physics, USA, [2]Dept. of Physics, Harvard Univ., USA, [3]Dept. of Physics, Yale Univ., USA, [4]Dept. of Applied Physics, Yale Univ., USA, [5]Inst. for Theoretical Physics, Univ. of Innsbruck, Austria.* Qubits encoded in longlived rotational states of polar molecules interact strongly with single photons of a superconducting stripline cavity. We discuss potential applications of such a hybrid device for quantum information processing.

QMC2 • 5:00 p.m.
Classical Logic Operations Using the Quantum Zeno Effect, *James D. Franson[1], B. C. Jacobs[2]; [1]Univ. of Maryland, Baltimore County, USA, [2]Applied Physics Lab, Johns Hopkins Univ., USA.* The quantum Zeno effect can be used to implement quantum logic operations using single photons as the qubits. It is shown here that similar effects can be used to implement classical logic and memory devices.

QMC3 • 5:15 p.m.
Tunable Setup for an Entire Family of Four-Photon Entangled States, *Witlef Wieczorek[1,2], Christian Schmid[1,2], Nikolai Kiesel[1,2], Roland Krischek[1,2], Harald Weinfurter[1,2]; [1]Max-Planck-Inst. for Quantum Optics, Germany, [2]Dept. of Physics, Ludwig-Maximilians-Univ. Munich, Germany.* We report on the experimental observation and analysis of an entire family of four-photon entangled states. We demonstrate how these states can be obtained with a single linear optics set-up and analyze particular entanglement properties.

QMC4 • 5:30 p.m.
Surface Polariton-Polariton Induced Transparency in Left-Handed Metamaterials, *Ali A. Kamli[1,2], Sergey A. Moiseev[1,3], Barry C. Sanders[1]; [1]Inst. for Quantum Information Science, Univ. of Calgary, Canada, [2]Dept. of Physics, King Khalid Univ., Saudi Arabia, [3]Kazan Physical-Technical Inst. of Russian Acad. of Sciences, Russian Federation.* We propose to control surface polariton (SP) propagation in left-handed materials. New spectral behavior of SP propagation is demonstrated due to the spatial properties of interaction between the SP modes and three level atoms.

QMC5 • 5:45 p.m.
Coherent Optical Spectroscopy of a Semiconductor Quantum Dot Cavity QED System in the Strong Coupling Regime, *Kartik Srinivasan[1], Oskar Painter[2]; [1]NIST, USA, [2]Caltech, USA.* Coherent optical spectroscopy of a strongly-coupled semiconductor microcavity-quantum dot system is performed using a fiber taper waveguide to efficiently access the system. Vacuum Rabi splitting under weak driving and saturation under strong driving are observed.

QMC6 • 6:00 p.m.
Weak Values and the Leggett-Garg Inequality in Solid-State Qubits, *Andrew N. Jordan, Nathan S. Williams; Dept. of Physics and Astronomy, Univ. of Rochester, USA.* An implementation of weak values is investigated in solid-state qubits. We demonstrate that a weak value can be non-classical if and only if a Leggett-Garg inequality can also be violated.

QMC7 • 6:15 p.m.
Toward Hyperentanglement via Semiconductor Two-Photon Emission, *Alex Hayat, Pavel Ginzburg, David Neiman, Serge Rosenblum, Meir Orenstein; Dept. of Electrical Engineering, Technion-Israel Inst. of Technology, Israel.* A novel phenomenon of semiconductor two-photon emission is presented experimentally. Based on this effect, we propose implementations of compact highly-efficient room-temperature sources of entangled photons (inter-band transitions in a microcavity) and hyperentangled photons (inter-subband transitions).

JMB • Joint Poster Session

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

JMB42
Coupling of N Qubits to Any Dicke State via Projective Measurements, *Christoph Thiel[1], Andreas Maser[1], Thierry Bastin[2], Enrique Solano[3], Joachim von Zanthier[1]; [1]Inst. for Optics, Information and Photonics, Univ. of Erlangen-Nuremberg, Germany, [2]Inst. de Physique Nucléaire, Atomique et de Spectroscopie, Univ. de Liège au Sart Tilman, Belgium, [3] Dept. of Physics, Arnold Sommerfeld Ctr. for Theoretical Physics and Ctr. for Nanoscience, Ludwig-Maximilians-Univ., Germany.* We propose a method mimicking the coupling of N qubits to a compound system using linear optics only. Our scheme employs N atoms with Λ-configuration and offers access to any of the 2^N Dicke states.

JMB43
Triple Quantum Correlations from an Above-Threshold Optical Parametric Oscillator, *Katiúscia N. Cassemiro, Alessandro S. Villar, Marcelo Martinelli, Paulo A. Nussenzveig; Inst. de Física, Univ. de Sao Paulo, Brazil.* We measured triple quantum correlations between the bright beams in an optical parametric oscillator, operating above threshold. Owing to extra noise in the system, still unaccounted for, tripartite entanglement is yet to be demonstrated.

JMB44
GHZ\W Type Tripartite Entanglement in Non-Interacting Fermi Gas, *Hessam Habibian[1], John W. Clark[2], Kurt Hingerl[3], Michael Bergmair[3]; [1]Christian Doppler Lab for Surface Optics, Inst. fur Halbleiter und Festkorperphysik, Johannes Kepler Univ. Linz, Austria, [2]Dept. of Physics, Washington Univ., USA, [3]Christian Doppler Lab for Surface Optics, Inst. für Halbleiter und Festkorperphysik, Austria.* We have considered GHZ\W entanglement in non-interacting Fermi gas. For this aim we have introduced new class of GHZ-Witnesses. We have shown that for tripartite Fermi systems GHZ\W entanglement as well as W-type exists.

JMB45
Topological Phase for Spin-Orbit Transformations on a Laser Beam, *Carlos Eduardo R. Souza[1], Jose Augusto O. Huguenin[1], Perola Milman[2], Antonio Z. Khoury[1]; [1]Inst. de Física, Univ. de Federal Fluminense, Brazil, [2]Lab de Materiaux et Phénomènes Quantiques, Univ. Paris Diderot, France.* We investigate the topological phase associated with the $SO(3)$ representation in terms of maximally entangled states. An experimental demonstration of this topological phase is provided for polarization and spatial mode transformations of a laser beam.

JMB46
Operator Quantum Fault Tolerance, *Gerald Gilbert[1], Michael Hamrick[1], Yaakov S. Weinstein[1], Vaneet Aggarwal[2], Robert Calderbank[2]; [1]MITRE, USA, [2]Princeton Univ., USA.* We introduce a universal operator theoretic framework for quantum fault tolerance that incorporates a top-down approach based on specification of the full system dynamics. This approach leads to more accurate error thresholds.

JMB47
Microscopic Cascading Induced by Local-Field Effects as a Tool for Quantum Lithography, *Ksenia Dolgaleva[1], Heedeuk*

Shin[1], Robert W. Boyd[1], John E. Sipe[2]; [1]Inst. of Optics, Univ. of Rochester, USA, [2]Dept. of Physics, Univ. of Toronto, Canada. We show that there are cascaded contributions from the third-order microscopic hyperpolarizability to the fifth-order susceptibility induced by local-field effects which can be useful in creating novel quantum lithographic materials.

JMB48

Operational Monitoring of Multi-Qubit Entanglement Classes via Tuning of Local Operations, *Thierry Bastin[1], Christoph Thiel[2], Joachim von Zanthier[2], Lucas Lamata[3], Enrique Solano[4], Girish S. Agarwal[5]; [1]Inst. de Physique Nucléaire, Atomique et de Spectroscopie, Univ. de Liège au Sart Tilman, Belgium, [2]Inst. for Optics, Information and Photonics, Max Planck Res. Group, Univ. of Erlangen-Nuremberg, Germany, [3]Max Planck Inst. for Quantum Optics, Germany, [4]Physics Dept., Arnold Sommerfeld Ctr. for Theoretical Physics and Ctr. for Nanoscience, Ludwig-Maximilians-Univ., Germany, [5]Dept. of Physics, Oklahoma State Univ., USA.* We show that for a system of N emitters, incoherently radiating single photons it is possible to associate well-defined sets of experimental parameters with multiqubit entanglement classes, allowing their monitoring in an operational manner.

JMB49

Two-Color Ghost Imaging, *Kam Wai C. Chan, Malcolm N. O'Sullivan, Mehul Malik, Robert W. Boyd; Inst. of Optics, Univ. of Rochester, USA.* We study a quantum ghost imaging system that uses different wavelengths to illuminate the object and the reference detector. We found that the resolution is limited by the wavelength of light illuminating the object.

JMB50

Master Equation in the Presence of Initial Correlation with Reservoir, *Kazuya Yuasa; Waseda Univ., Japan.* We discuss the derivation of Markovian master equation via Nakajima-Zwanzig's projection operator method, when there exists initial correlation between the system and the reservoir.

JMB51

Experimental Test of Non-Local Realism Using a Fiber-Based Source of Polarization-Entangled Photon Pairs, *Matthew D. Eisaman, Elizabeth Goldschmidt, Jingyun Fan, Alan Migdall; NIST, USA.* We test local realistic and non-local realistic theories using a fiber-based source of polarization-entangled photons. Our measurements violate local (certain non-local) hidden-variable theories by 14 (3) standard deviations.

JMB52

Withdrawn

JMB53

Entanglement Stabilization via Quantum Feedback, *André R. R. Carvalho[1], Joseph J. Hope[2]; [1]Dept. of Physics, Australian Natl. Univ., Australia, [2]Australian Ctr. for Quantum-Atom Optics, Dept. of Physics, Faculty of Science, Australian Natl. Univ., Australia.* We describe how feedback methods can be implemented to produce and stabilize entangled states of two atoms inside a cavity. The scheme overcomes fundamental decoherence sources, and is mostly insensitive to practical imperfections.

JMB54

DLCZ Quantum Repeaters: Rate and Fidelity Analysis, *Jeyran Amirloo, Mohsen Razavi, A. Hamed Majedi; Univ. of Waterloo, Canada.* The fidelity and the rate of entanglement generation for the DLCZ entanglement-swapping protocol are evaluated. We find the distance beyond which DLCZ repeaters outperform single DLCZ links by accounting for loss, multiple-excitation, and self-purification effects.

JMB55

Recurrences in Quantum Walks, *Martin Stefanak[1], Igor Jex[1], Tamas Kiss[2]; [1]Czech Technical Univ., Czech Republic, [2]Res. Inst. for Solid State Physics and Optics, Hungarian Acad. of Sciences, Hungary.* We analyze the recurrence probabilities (Pólya numbers) of quantum walks. We show that one can achieve strikingly different recurrence behaviours for quantum walks by altering the coin and the initial state.

JMB56

BB84 Quantun Key Distribution without a Shared Reference Frame, *C. E. R. Souza[1], C. V. S. Borges[1], A. Z. Khoury[1], J. A. O. Huguenin[2], L. Aolita[3], S. P. Walborn[3]; [1]Inst. de Física, Univ. Federal Fluminense, Brazil, [2]Dept. de Ciências Exatas, Univ. Federal Fluminense, Brazil, [3]Inst. de Física, Univ. Federal do Rio de Janeiro, Brazil.* We report a simple quantum key distribution experiment in which a shared reference frame is not necessary. Logical qubits are encoded into non-separable states of polarization and first-order transverse spatial modes of the same photon.

JMB57

Effect of Dispersion on Fidelity of a Quantum Interferometer, *Thomas B. Bahder[1], Alexander V. Sergienko[2], David S. Simon[2]; [1]Charles M. Bowden Res. Facility, Aviation and Missile Res., Development and Engineering Ctr., US Army Res. Development Command, USA, [2]Dept. of Electrical and Computer Engineering, Boston Univ., USA.* We analyze the effect of frequency dispersion on the Shannon mutual information for high-resolution phase measurement with Mach-Zehnder interferometers, comparing input states of monochromatic photons to those of nonzero-bandwidth photons produced by parametric downconversion.

JMB58

Dynamics of Entangled Coherent States under Dissipation, *Freddy Antonio Peres Lastra[1], Guillermo E. S. Romero[1], Carlos E. Lopez[1], Nicim Zagury[2], Juan C. Retamal[1]; [1]Univ. de Santiago de*

Chile, Chile, [2]Univ. Federal do Rio de Janeiro, Brazil. We discuss the loss of entanglement under dissipation for a class of entangled coherent states of two modes of the electromagnetic field. Both asymptotic decays and finite disentanglement occur depending of the initial conditions.

JMB59

A Parametric Down-Conversion Source for Two-Photon Absorption Experiments, *Todd B. Pittman, Scott Hendrickson, Jim D. Franson; Univ. of Maryland, Baltimore County, USA.* We describe a Parametric Down-Conversion source based on a low-power (< 1mW), narrowband (<1 MHz) fiber-coupled pump laser. The source is designed for two-photon absorption experiments related to quantum Zeno gates.

JMB60

Photon Energy Entanglement Characterization by Electronic Transition Interference, *Alex Hayat, Pavel Ginzburg, Meir Orenstein; Dept. of Electrical Engineering, Technion-Israel Inst. of Technology, Israel.* Direct characterization of photon energy-entanglement, full Bell-state analysis and energy-qubit detection are proposed, based on a coherent-control concept of two-photon absorption interferometry of electronic transition amplitudes rather than of photons, within practical room-temperature semiconductor detectors.

JMB61

Entangling Schrödinger Cats: Methods, Measures and Statistics, *Mayer A. Landau, Carlos R. Stroud Jr.; Inst. of Optics, Univ. of Rochester, USA.* We study wavepacket entanglement using generalized Schrödinger cat states of collections of oscillators with time dependent interactions. Entanglement is characterized as a function of pulse area using a generalized entanglement measure, and generalized displacement operator.

JMB62

Entangled Coherent States, Heisenberg-Limited Metrology, and Related Issues, *Christopher C. Gerry, Adil Benmoussa; Dept. of Physics and Astronomy, Lehman College, CUNY, USA.* We discuss the generation of two mode maxinally entangled coherent states using a weak nonlinear medium. We then discuss their applications to quantum metrology (Heisenberg-limited interferometry), quantum lithography and violations of Bell-type inequalities.

JMB63

A New Scheme for Nuclear Spin Quantum Memory in an Isotope-Controlled Si Quantum Dot, *Ozgur Cakir[1,2], Toshihide Takagahara[1,2]; [1]Kyoto Inst. of Technology, Japan, [2]Core Res. for Evolutional Science and Technology, Japan Science and Technology Agency, Japan.* A new scheme for the nuclear spin quantum memory and the photon-electron quantum state transfer is proposed based on the singlet-triplet crossing of two electrons in a Si quantum dot with a single ^{29}Si isotope.

JMB64

Free Space Quantum Key Distribution System with Atmospheric Turbulence Mitigation by Active Deformable Mirror, *Ivan Capraro[1], Tommaso Occhipinti[1], Stefano Bonora[2], Paolo Villoresi[1]; [1]Univ. of Padova, Italy, [2]Univ. of Padova and Lab for Ultraviolet and X-Ray Optical Res., Inst. Natl. per la Fisica della Materia, Consiglio Natl. delle Ricerche, Italy.* Propagation through atmosphere is a major limitation in free space QKD implementations. Adaptive Optics can be a solution to this problem. This paper describes some results in this direction we obtained with our QKD setup.

JMB65

Coherent States Engineering with Linear Optics, *Bing He, János Bergou; Dept. of Physics and Astronomy, Hunter College, CUNY, USA.* We present a general linear optics based approach to implement contractive transformations that map products of N coherent states to products of M coherent states (M≤N) and apply it to nondestructive quantum database search.

JMB66

Separable Operations on Pure States, *Vlad Gheorghiu, Robert B. Griffiths; Carnegie Mellon Univ., USA.* Numerical evidence provides strong support for the conjecture that the ensemble resulting from a separable operation applied to a single bipartite pure state can be produced by some LOCC operation acting on the same state.

JMB67

Simulation of the Quantum Decoherence Effect for $^{79}Br^{85}Rb$, *R. A. Betancur; Univ. Natl. de Colombia, Colombia.* Decoherence effect on the density matrix of molecule $^{79}Br^{85}Rb$ using Brownian particle model in high temperature limit is simulated and the implied variables in this evolution are revealed which gives insight to avoid this limitation.

JMB68

Entanglement, Postselection and Precise Inferences in Joint Measurements of Incompatible Observables, *Alonso Botero; Univ. de los Andes, Colombia.* We discuss conditions under which joint outcomes of simultaneous measurements of non-commuting canonical observables can be inferred with arbitrary precision. The feat is possible for certain pre- and postselections involving entanglement with ancillary systems.

JMB69

Spin-Induced Non-Geodesic Motion, Wigner Rotation and Entanglement of Massive Spin-1/2 Particles in a Gravitational Field, *Paul M. Alsing[1], G.J. Stephenson[1], Patrick Kilian[2]; [1]Univ. of New Mexico, USA, [2]Bayrische Julius-Maximilians Univ. Würzburg, Germany.* We develop the

Wigner rotation for spin 1/2 particles moving in curved spacetimes, and include the spin-orbit coupling of the particle's motion to the gravitational curvature. We then investigate entanglement in curved spacetimes.

JMB70

Quantum Control of Entanglement by Phase Manipulation, *Vladimir S. Malinovsky; MagiQ Technologies Inc., USA.* A method of entangled states preparation of two-qubit systems is proposed. The method combines the techniques of coherent control by manipulation of the relative phase between pulses, and adiabatic control using time-delayed pulse sequences.

JMB71

Exact Results on Decoherence and Entanglement in a Cavity QED System of N Driven Atoms and One Dissipative Field Mode, *Matteo Bina, Federico Casagrande, Alfredo Lulli; Dept. di Fisica, Univ. di Milano, Italy.* The general solution allows investigating and monitoring decoherence, entanglement and purity of the system and the subsystems. Particular entangled atomic states can be frozen in decoherence-free subspaces for quantum information purposes.

JMB72

Electromagnetically Induced Transparency on Semiconductor Quantum Well Structure, *Hoonsoo Kang, Jong Su Kim, Clare C. Byeon, Mun Seok Jeong, Do-Kyeong Ko, Jongmin Lee; Advanced Photonics Res. Inst., Gwangju Inst. of Science and Technology, Republic of Korea.* We observed electromagnetically induced transparency on GaAs/AlGas quantum well structure. EIT signal was observed at various conditions including delay time, coupling beam intensity, polarization state of probe-coupling beam and temperature.

JMB73

Quantum Squeezing and Correlation of Slow-Light Self-Induced Transparency Solitons, *Ray-Kuang Lee[1], Yinchieh Lai[2,3]; [1]Inst. of Photonics Technologies, Natl. Tsing-Hua Univ., Taiwan, [2]Dept. of Photonics, Natl. Chiao-Tung Univ., Taiwan, [3]Res. Ctr. for Applied Sciences, Academic Sinica, Taiwan.* A quantum theory of self induced transparency solitons is developed with quantum effects of ensemble atoms taken into account. Suggestions for experimental SIT soliton squeezing detection and intersoliton correlation generation are given.

JMB74

Conditions to Preserve Quantum Entanglement of Quadrature Fields through an Eletctromagnetally Induced Transparency Medium, *Yu-Lin Chuang[1], Ray-Kuang Lee[1,2]; [1]Dept. of Photonics, Natl. Chiao-Tung Univ., Taiwan, [2]Inst. of Photonics Technologies, Natl. Tsing-Hua Univ., Taiwan.* We study the entanglements among three quadrature fields, two of them interacting through an electromagnetically induced transparency medium while two are generated by a two-mode squeezer. We show the conditions to preserve non-separation criteria.

JMB75

Quantum Key Distribution Using Magnetostatic Wave-Optical Interactions, *Anil Prabhakar, Pradeep Kumar; Indian Inst. of Technology, Madras, India.* We propose quantum key distribution using magnetostatic wave optical interactions in garnet films at telecommunication wavelengths. The simultaneous change in optical frequency and polarization is advantageous in an implementation of the B92 protocol.

JMB76

Continuous-Variable Teleportation: A New Look, *Paulina Marian, Tudor A. Marian; Univ. of Bucharest, Romania.* We show that the amount of noise distorting the properties of the input field state in the continuous-variable teleportation rigorously equals the EPR–uncertainty of the resource state.

JMB77

Security Evaluation of Dual-Threshold Homodyne Quantum Cryptographic Systems, *Manuel Sabban[1], Qing Xu[1], Philippe Gallion[1], Francisco Mendieta[1,2]; [1]Ecole Natl. Supérieure des Télécommunications (Télécom ParisTech), France, [2] Center for Scientific Investigation and Higher Education (CICESE), Mexico.* In this work we present a quantitative security analysis of a dual-threshold homodyne quantum cryptography with two types of possible eavesdropping attacks in terms of the differential of mutual information.

JMB78

Vortex-Antivortex Labyrinth Wavefunction, *Alexey Y. Okulov; A.M. Prokhorov General Physics Inst., Russian Acad. of Sciences, Russian Federation.* The vortex-antivortex optical trapping arrays are shown to transfer angular orbital momentum to support "antiferromagnet-like" matter waves. The wavefunction's phase gradient field associated with the field of classical velocities via Madelung transformation forms labyrinth-like structure.

JMB79

Entanglement Dynamics and Geometry of Quantum States: Calculations and Simulations, *Marcelo F. Santos; Univ. Federal de Minas Gerais, Brazil.* We analyze the dynamical behavior of entangled systems under the action of decoherence and its relation to the geometry of quantum states. Physical examples and an experimental simulation are also presented.

JMB80

Hyperfine Interaction Induced Decoherence and Quantum Information Processing with Quantum Dots, *Yechao Zhu[1], Siqing Yu[1], Ye Yeo[2]; [1]Hwa Chong Inst., Singapore, [2]Dept. of Physics, Natl. Univ. of Singapore, Singapore.* Employing a realistic model of the nuclear spin bath, we derive exact dynamical mappings that describe the basic operations in quantum information processing with electron spin qubits in quantum dots.

JMB1-JMB9 can be found in the COTA abstracts.
JMB10-JMB33 can be found in the Slow Light abstracts.
JMB34-JMB41, JMB81 can be found in the IPNRA abstracts.

NOTES

• 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

QTuA • Entanglement III

Salons H–J
10:30 a.m.–12:30 p.m.
QTuA • Entanglement III
Saverio Pascazio; Univ. di Bari, Italy, Presider

QTuA1 • 10:30 a.m. **Invited**
The Quantum Cost of a Nonlocal Measurement, *Somshubhro Bandyopadhyay[1], Shelby Kimmel[2], William K. Wootters[2]; [1]Univ. de Montréal, Canada, [2]Williams College, USA.* For any measurement on two spatially separated objects, one can ask how much quantum communication the measurement requires. Here we place upper and lower bounds on this quantity for a simple two-qubit measurement.

QTuA2 • 11:00 a.m. **Invited**
Phase Transitions in the Statistics of Bipartite Entanglement, *Antonello Scardicchio; Princeton Univ., USA.* We study a random matrix model for the statistics of bipartite entanglement. We find two phase transitions, characterized by different Schmidt spectra. One critical phase is described by a theory of random surfaces.

QTuA3 • 11:30 a.m. **Invited**
Single Atom – Single Photon Interfaces, *F. Rohde, C. Schuck, M. Hennrich, M. Almendros, A. Haase, N. Piro, F. Dubin, M. Mitchell, R. Gehr, Juergen Eschner; ICFO - Inst. of Photonic Sciences, Spain.* In an experimental system of two distant ion traps we trap simultaneously strings of Ca^+ ions and observe Hong-Ou-Mandel interference between their scattered photons. We also generate entangled photon pairs whose frequency and bandwidth are matched to an absorption line in the ions, and work towards heralded single photon – single ion interaction.

QTuA4 • 12:00 p.m.
Transforming Entanglement without Communication, *Bing He, János Bergou; Dept. of Physics and Astronomy, Hunter College, CUNY, USA.* We present a local unitary operation strategy to realize the transformations between bi-partite entangled pure states without any communication between the sharing parties. It also saves the interaction with an ancilla in implementing the transformations.

QTuA5 • 12:15 p.m.
Entanglement on Demand through Time Reordering, *Joseph E. Avron[1], Gili Bisker[1], David Gershoni[1], Netanel H. Lindner[1], Eli A. Meirom[1], Richard J. Warburton[2]; [1]Dept. of Physics, Technion-Israel Inst. of Technology, Israel, [2]School of Engineering and Physical Sciences, Heriot-Watt Univ., UK.* Entangled photons can be generated on demand in a novel scheme involving unitary time reordering of the photons emitted in a radiative decay. This scheme can be applied to the biexciton cascade in quantum dots.

12:30 p.m.–2:00 p.m.
Lunch Break

QTuB • Quantum Imaging and Emerging Topics

Salons H–J
2:00 p.m.–4:00 p.m.
QTuB • Quantum Imaging and Emerging Topics
Wolfgang Schleich; Dept. of Quantum Physics, Univ. of Ulm, Germany, Presider

QTuB1 • 2:00 p.m. **Invited**
The Physics of Ghost Imaging, *Yanhua Shih; Univ. of Maryland, Baltimore County, USA.* Two types of ghost imaging have been experimentally demonstrated since 1995. Type-one ghost imaging uses entangled photon pairs and type-two ghost imaging uses chaotic light. This talk will explore and analyze the quantum nature of both type-one and type-two ghost imaging.

QTuB2 • 2:30 p.m.
X-Entanglement of PDC Photon Pairs, *Alessandra Gatti, Lucia Caspani, Enrico Brambilla, Ottavia Jedrkiewicz, Luigi A. Lugiato;*

Inst. Natl. per la Fisica della Materia, Consiglio Natl. delle Ricerche, CNISM and Dept. di Fisica e Matematica, Univ. dell'Insubria, Italy. The X-wave picture is adopted to describe the spatio-temporal entanglement of PDC photons. Key elements of novelty are the non-factorability of the state and the extreme relative localization of photons in space and time.

QTuB3 • 2:45 p.m.
Single Photon Image Discrimination, *Curtis J. Broadbent[1], John C. Howell[1], Heedeuk Shin[2], Petros Zerom[2], Robert W. Boyd[2]; [1]Dept. of Physics and Astronomy, Univ. of Rochester, USA, [2]Inst. of Optics, Univ. of Rochester, USA.* We present experimental results demonstrating image discrimination with a single photon. A multiplexed hologram is used to distinguish between two single photon images with a confidence of greater than 93.4% without requiring an ensemble.

QTuB4 • 3:00 p.m.
Resonant Interferometric Lithography beyond the Diffraction Limit, *Jörg Evers[1], Martin Kiffner[1], M. Suhail Zubairy[1,2]; [1]Max-Planck-Inst. für Kernphysik, Germany, [2]Texas A&M Univ. at Qatar, Qatar.* We discuss interferometric optical subwavelength lithography using resonant light-matter interactions only. As compared to previous schemes, no multiphoton processes are required, such that the scheme works at low light intensities.

QTuB5 • 3:15 p.m.
Quantum Imaging with Single Photon Sources, *Joachim von Zanthier[1], Christoph Thiel[1], Thierry Bastin[2], Girish S. Agarwal[3]; [1]Inst. for Optics, Information and Photonics, Univ. of Erlangen-Nuremberg, Germany, [2]Inst. de Physique Nucléaire, Atomique et de Spectroscopie, Univ. de Liège au Sart Tilman, Belgium, [3]Dept. of Physics, Oklahoma State Univ., USA.* We propose to employ photons emitted from single photon sources to image a physical object of sub-wavelength size with 100% contrast by making use of joint detection probabilities.

QTuB6 • 3:30 p.m.
Quantum Illumination: Enhanced Background-Limited Target Detection by Means of Entanglement, *Si-Hui Tan[1], Baris I. Erkmen[1], Vittorio Giovannetti[2], Saikat Guha[1], Seth Lloyd[1], Lorenzo Maccone[3], Jeffrey H. Shapiro[1]; [1]MIT, USA, [2]Scuola Normale Superiore, Italy, [3]Univ. degli Studi di Pavia, Italy.* Use of an entangled-state transmitter is shown to provide a significant performance advantage—in comparison to a coherent-state transmitter—in background-limited target detection, even though the received state is not entangled.

QTuB7 • 3:45 p.m.
Individual Addressing of Trapped Ions and Coupling of Motional and Spin States Using rf Radiation, *M. Johanning[1], A. Braun[1], N. Timoney[1], V. Elman[1], W. Neuhauser[2], Chr. Wunderlich[1]; [1]Univ. of Siegen, Germany, [2]Univ. of Hamburg, Germany.* Two essential steps towards a novel concept for quantum information science—an ion spin molecule—are demonstrated for the first time: Individual rf-addressing of trapped ions and spin-motion interaction induced by an rf-field.

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

QTuC • Decoherence and Algorithms

Salons H–J
4:30 p.m.–6:30 p.m.
QTuC • Decoherence and Algorithms
Zdenek Hradil; Dept. of Optics, Palacky Univ., Czech Republic, Presider

QTuC1 • 4:30 p.m. Invited
Non-Markov Control of Quantum Thermodynamics in Multipartite Systems, *Gershon Kurizki; Dept. of Chemical Physics, Weizmann Inst. of Science, Israel.* We predict drastic deviations from ordinary thermodynamic trends, which are monotonic approach to thermal equilibrium and positive entropy production, when qubits coupled to bosonic baths are probed on non-Markovian time scales by quantum nondemolition measurements.

QTuC2 • 5:00 p.m.
Controlled Dephasing of a Quantum Dot Resonance, *Daniel Rohrlich[1], Oren Zarchin[2], Moty Heiblum[2], Diana Mahalu[2], Vladimir Umansky[2]; [1]Dept. of Physics, Ben Gurion Univ., Israel, [2]Dept. of Condensed Matter Physics, Weizmann Inst. of Science, Israel.* We couple electrons passing through a two-slit interferometer to electrons tunneling through a Fabry-Perot interferometer (a quantum dot) at resonance, and demonstrate that the mutual detection of these interferometer currents dephases and suppresses the resonance.

QTuC3 • 5:15 p.m. Invited
Factorization of Numbers and Gauss Sums, *Wolfgang Schleich; Dept. of Quantum Physics, Univ. of Ulm, Germany.* Gauss sums play an important role in number theory as well as quantum physics. We present schemes based on Gauss sums to factor large numbers. We review recent experiments and discuss possible extension using entanglement.

QTuC4 • 5:45 p.m. Invited
Quantum Walks–Types and Properties, *Igor Jex[1], Martin Stefanak[1], Tamas Kiss[2]; [1]Czech Technical Univ., Czech Republic, [2]RISPO Hungarian Acad. of Sciences, Hungary.* We review properties of quantum walks with one and two excitations. The Polya number concept is applied to quantum walks and used for their classification. Quantum walks with random

errors leading to localization are discussed.

QTuC5 • 6:15 p.m.
Quantum Walks on Highly Symmetric Graphs, *Mark Hillery; Dept. of Physics, Hunter College, CUNY, USA.* We study discrete-time quantum walks on the complete and bipartite graphs, and show how they can be used to perform searches. The symmetry of the graphs significantly reduces the dimension of the problem.

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

QWA • Entanglement IV

Salons H–J
8:00 a.m.–10:00 a.m.
QWA • Entanglement IV
Alessandra Gatti; CNR-CNISM and Univ. dell' Insubria, Italy, Presider

QWA1 • 8:00 a.m. **Invited**
A Universal Set of Quantum Gates on Trapped Ions in a Decoherence-Free Subspace, *Hartmut Häffner; Inst. für Quantenoptik und Quanteninformation, Austria.* Pairs of trapped ions can store quantum information four orders of magnitude longer than single ions. We will discuss the realization of a universal set of quantum gates acting on such a decoherence-free suspace.

QWA2 • 8:30 a.m. **Invited**
Probing Quantum Rules with Single-Photon Creation and Annihilation Operators, *Marco Bellini; Inst. Nazionale di Ottica Applicata and LENS/Univ. of Florence, Italy.* We experimentally apply simple sequences of photon creation and annihilation operators to a light field. By a tomographic analysis of the resulting light states we provide the first direct test of quantum non-commutativity.

QWA3 • 9:00 a.m. **Invited**
One-Way Quantum Computation with Two-Photon Multiqubit Cluster States, *Paolo Mataloni; Univ. degli Studi di Roma, Italy.* We demonstrate one-way quantum computation by using cluster states of two photons and four-qubits. General single qubit rotations, either probabilistic or deterministic, and efficient C-NOT and C-Phase gates have been realized by this technique.

QWA4 • 9:30 a.m.
Strongly Correlated Photon Transport in One-Dimensional Systems, *Jung-Tsung Shen, Shanhui Fan; Stanford Univ., USA.* We show that two-photon transport is strongly correlated in one-dimensional waveguide coupled to a two-level system. Moreover, we show that the two-level system can induce effective attractive or repulsive interactions in space for photons.

QWA5 • 9:45 a.m.
Delay of Quantum Correlations with an Atomic System, *Alberto M. Marino, Raphael C. Pooser, Vincent Boyer, Paul D. Lett; NIST, USA.* We use a four-wave mixing process in an atomic system to delay quantum correlations in twin beams. We have obtained a delay of 13 ns without a significant degradation of the intensity-difference squeezing.

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

QWB • Optical and Other Implementations II, Quantum State Reconstruction, Storage I

Salons H–J
10:30 a.m.–12:30 p.m.
QWB • Optical and Other Implementations II, Quantum State Reconstruction, Storage I
Yanhua Shih; Univ. of Maryland, Baltimore County, USA, Presider

QWB1 • 10:30 a.m. **Invited**
Tomography for Quantum Diagnostics, *Zdenek Hradil[1], Jaroslav Rehacek[1], Dmitri Mogilevtsev[2]; [1]Palacky Univ. Olomouc, Czech Republic, [2]Inst. of Physics, Belarus.* We introduce a resolution measure, which provides error bars for any quantity inferred from tomographic measurement. Method is illustrated with the diagnostics of non-classical behavior using homodyne tomography and Wigner function at the origin.

QWB2 • 11:00 a.m.
Experimental Quantum State Tomography in Mutually Unbiased Bases, *Robert B. A. Adamson, Aephraim M. Steinberg; Dept of Physics, Univ. of Toronto, Canada.* We present the first experiment in two-qubit quantum state tomography to take advantage of mutually unbiased bases. Measuring in these bases extracts the maximum information from a fixed number of copies of the state.

QWB3 • 11:15 a.m.
Experimental Quantum State Tomography of a Solid-State Qubit, *Andreas Walther, Lars Rippe, Brian Julsgaard, Stefan Kröll; Dept. of Physics, Lund Inst. of Technology, Sweden.* An ensemble of Pr^{3+} ions is prepared inside a zero-absorption spectral hole, to act as a qubit. Quantum state tomography with robust pulses, to compensate for inhomogeneities, is demonstrated with >90% fidelity.

QWB4 • 11:30 a.m.
Holey Fiber Microcavities, *Scott M. Hendrickson, Todd B. Pittman, James D. Franson; Physics Dept., Univ. of Maryland, Baltimore County, USA.* Microcavities have been formed by placing mirrors on the ends of a short section of holey fiber. The resonant behavior of these devices was analyzed and their suitability for use in nonlinear-optics experiments was evaluated.

QWB5 • 11:45 a.m.
Quantum Information Processing with Optical Fibers, *Jeremie Fulconis[1], Alexander Clark[1], Matthaeus Halder[1], Jeremy L. O'Brien[1], John G. Rarity[1], Chunle Xiong[2], William J. Wadsworth[2]; [1]Univ. of Bristol, UK, [2]Univ. of Bath, UK.* We demonstrate a fiber implementation of a Controlled-NOT gate using a fiber source of heralded single photons and three partially polarising couplers. We also investigate a new phase-matching scheme for pure state single photon generation.

QWB6 • 12:00 p.m.
Photon-Hole Nondemolition Measurement by Quantum Interference, *Alex Hayat, Pavel Ginzburg, David Neiman, Serge Rosenblum, Meir Orenstein; Dept. of Electrical Engineering, Technion-Israel Inst. of Technology, Israel.* We propose a quantum nondemolition measurement of photon-holes by electromagnetically-induced transparency schemes. Upon photon-hole arrival the destructive interference of electron transition amplitudes is destroyed, resulting in absorption of a drive photon, preserving the photon-hole state.

QWB7 • 12:15 p.m.
Deterministic Spin Entangler and Photon Entangler Using a Charged Quantum Dot in a Microcavity, *C. Y. Hu[1], W. J. Munro[2], A. Young[1], J. L. O'Brien[1], J. G. Rarity[1]; [1]Univ. of Bristol, UK, [2]Hewlett-Packard Labs, UK.* We present a deterministic photon-spin entangling gate using a charged quantum dot in a microcavity. This gate can be used for quantum non-demolition measurement of spin, spin entanglement, photon entanglement and as photon-spin quantum interface.

12:30 p.m.–2:00 p.m.
Lunch Break

QWC • Quantum Communication

Salons H–J
2:00 p.m.–4:00 p.m.
QWC • Quantum Communication
Mark Hillery; CUNY Hunter College, USA, Presider

QWC1 • 2:00 p.m. **Invited**
An Exponential Separation between the Entanglement and Communication Capacities of a Bipartite Unitary Interaction, *Debbie Leung; Univ. of Waterloo, Canada.* We consider asymptotic capacities of bipartite unitary gates. We present a gate with exponentially larger entanglement capacity than the total communication capacity. The key tool is a communication-efficient method to identify a bipartite quantum state.

QWC2 • 2:30 p.m. **Invited**
Unambiguous Preparation of Non-Orthogonal Quantum States, *Fabian Torres-Ruiz[1], José Aguirre[1], Aldo Delgado[1], G. Lima[1], Sebastiao Pádua[1,2], Luis Roa[1], Carlos Saavedra[1]; [1]Dept. de Física, Univ. de Concepción, Chile, [2]Dept. de Física, Univ. Federal de Minas Gerais, Brazil.* A probabilistic method for the unambiguous preparation of non-orthogonal polarization states is proposed. We show experimentally how this protocol is implemented by using two-photon states generated in the process of down conversion.

QWC3 • 3:00 p.m.
Experimental Restoration of Entanglement on an Entanglement Breaking Quantum Channel, *Fabio Sciarrino[1,2], Eleonora Nagali[1], Francesco De Martini[1,3], Radim Filip[4], Miroslav Gavenda[4]; [1]Univ. di Roma, Italy, [2]Ctr. di Studi e Richerche "Enrico Fermi," Italy, [3]Accademia Natl. dei Lincei, Italy, [4]Dept. of Optics, Palacky Univ., Czech Republic.* A new method revealing entanglement from a single photon entanglement breaking channel is proposed and experimentally verified. Via detection of noise leaving channel, the entanglement can be restored and further enhanced by single-copy entanglement filtration.

QWC4 • 3:15 p.m.
Spectrally Bright and Broad Fiber-Based Heralded Single-Photon Source, *Elizabeth A. Goldschmidt, Matthew D. Eisaman, Jingyun Fan, Sergey V. Polyakov, Jun Chen, Alan Migdall; NIST, USA.* We report the development of a spectrally bright and broad heralded single-photon source based on spontaneous four-wave-mixing in a single-mode fiber, measuring the second-order correlation function, $g^{(2)}(0)$, far below unity over a broad spectral range.

QWC5 • 3:30 p.m.
Space-to-Ground Single-Photon Link for the Realization of a Space Quantum Channel, *Paolo Villoresi[1], Thomas Jennewein[2], Fabrizio Tamburini[3], Markus Aspelmeyer[2,4], Cristian Bonato[1], Rupert Ursin[4], Claudio Pernechele[5], V. Luceri[6], Giuseppe Bianco[7], Anton Zeilinger[2,4], Cesare Barbieri[3]; [1]Dept. of Information Engineering, Univ. of Padova and Lab for Ultraviolet and X-Ray Optical Res., Inst. Natl. per la Fisica della Materia, Consiglio Natl. delle Ricerche, Italy, [2]Inst. for Quantum Optics and Quantum Information (IQOQI), Austrian Acad. of Sciences, Austria, [3]Dept. of Astronomy, Univ. of Padova, Italy, [4]Faculty of Physics, Inst. for Experimental Physics, Univ. of Vienna, Austria, [5]Inst. Natl. di Astrofisica-Cagliari, Italy, [6]e-GEOS S.p.A, Ctr. di Geodesia Spaziale "G. Colombo," Italy, [7]Ctr. di Geodesia Spaziale "G. Colombo," Agenzia Spaziale Italiana, Italy.* We present the experimental study of a quantum-channel between an orbiting source and a ground receiver. Different geodynamic satellites were used as a single-photon-source, obtaining an effective link with Ajisai at the distance of 1650-km.

QWC6 • 3:45 p.m.
Optimal Individual Attacks Against BB84, *Raul Garcia-Patron, Franco N. C. Wong, Jeffrey H. Shapiro; Res. Lab of Electronics, MIT, USA.* An economical version of asymmetric phase-covariant cloning is shown to provide an optimal

individual attack on the BB84 protocol with error correction that can be physically simulated using deterministic single-photon two-qubit quantum logic.

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

QWD • Metrology, Storage II and Transfer of Quantum Information; Emerging Topics

Salons H–J
4:30 p.m.–6:30 p.m.
QWD • Metrology, Storage II and Transfer of Quantum Information; Emerging Topics
William K. Wootters; Williams College, USA, Presider

QWD1 • 4:30 p.m. **Invited**
Partial Measurement Based Quantum Operations, *Gerd Leuchs; Inst. für Optik, Information und Photonik, Germany.* Partial measurements play an important role in several quantum information protocols with discrete and continuous variables such as state generation and cloning. Here we report on distillation of entanglement in the presence of non-Gaussian noise.

QWD2 • 5:00 p.m. **Invited**
Electromagnetically-Induced Transparency with Squeezed Light, *Alexander Lvovsky; Univ. of Calgary, Canada.* We investigate propagation and storage of pulses of squeezed vacuum in rubidium vapor under the conditions of electromagnetically-induced transparency. Quantum states of retrieved pulses are characterized by optical homodyne tomography.

QWD3 • 5:30 p.m. **Invited**
Quantum Computing and Its Applications to Hybrid Quantum Repeaters, *Kae Nemoto; Natl. Inst. of Informatics, Japan.* Qubus computation is a type of quantum information processing where qubits couple through quantum bus (qubus). Exploring its hybrid and distributed nature, we investigate the characteristics of a quantum repeater protocol of the qubus type.

QWD4 • 6:00 p.m.
Where Is the Quantum Particle between Two Position Measurements? *Lev Vaidman; Physics Dept., Tel Aviv Univ., Israel.* A controversy about counterfactual computation reveals a paradoxical feature of a pre- and post-selected quantum particle: it can reach a certain location without being on the path that leads to and from this location.

QWD5 • 6:15 p.m.
Experimental Optomechanics with Single and Twin Moving Mirrors, *Pierre-Francois Cohadon, Chiara Molinelli, Pierre Verlot, Aurélien Kuhn, Tristan Briant, Antoine Heidmann; Lab Kastler Brossel, Univ. Pierre et Marie Curie, France.* We present experiments where the motion of micro-mirrors is optically monitored with a quantum-limited sensitivity. Direct effects of radiation pressure on single and twin-mirror cavities are experimentally demonstrated. Applications to quantum optics are discussed.

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

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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.
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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

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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.

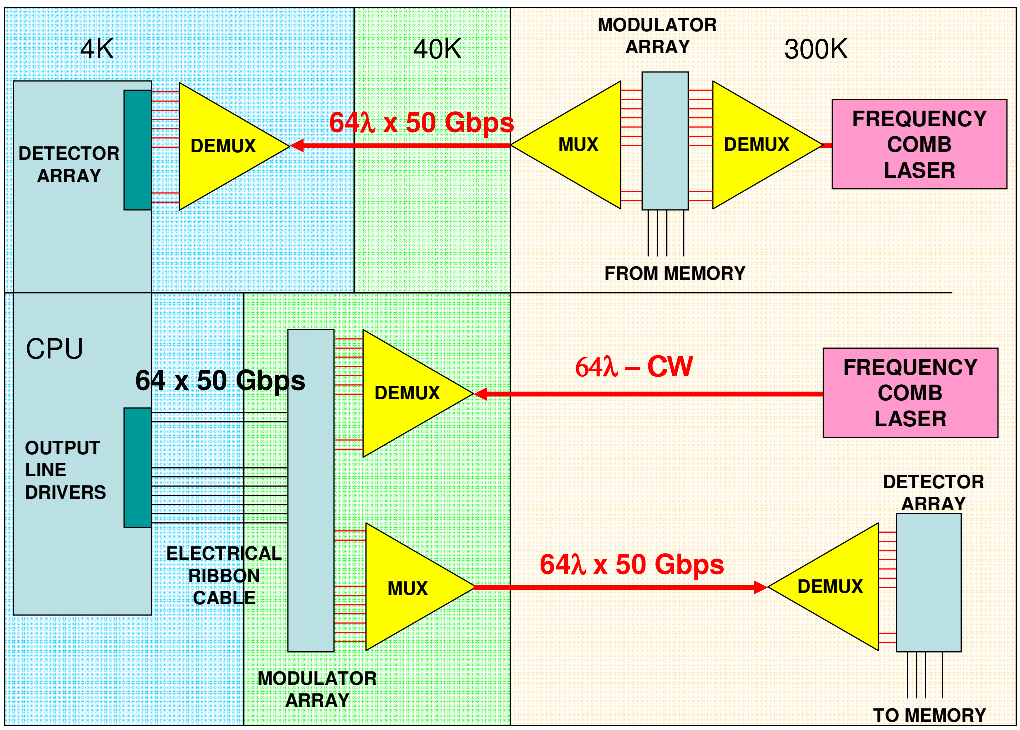

Figure 1: A 3 fiber, 64 wavelength, 50 Gbps DWDM System for bidirectional transmission totaling 6.4 Tbps between each of 4096 superconductor processors at 4K and mass memory at 300K**.**

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).