07:00–18:00 Registration Open, *Baltimore Convention Center, Pratt Street, 300 Level Lobby*

08:00–09:45 QThA • Electro-Magnetic Metamaterials

Gennady Shvets, Univ. of Texas at Austin, USA, Presider

QThA1 • 08:00
Metamaterial Blazed Gratings, *Yu-Ju Tsai[1], Stéphane Larouche[1], Talmage Tyler[1], Guy Lipworth[1], Jack J. Mock[1], Nan M. Jokerst[1], David R. Smith[1]; [1]Electrical and Computer Engineering, Duke Univ., USA.* We design, fabricate, and test a graded index diffractive structure based on non-resonant I-beam metamaterials. The measured diffraction spectrum is in good agreement with simulation, and suggests a path toward metamaterial based diffractive optics.

QThA2 • 08:15
Passive Resonance Tuning through Closely Spaced Coupled Split Ring Resonators, *Matthew T. Reiten[1], Dibakar Roy Chowdhury[1], Jianfeng Zhou[1], John F. O'Hara[1], Antoinette J. Taylor[2], Abul Azad[1]; [1]Center for Integrated Nanotechnologies, Los Alamos National Lab, USA; [2]Materials Physics and Applications Division, Los Alamos National Lab, USA.* Bilayer split ring resonators as a function of separation (~λ /500) and orientation are measured. Terahertz measurements match simulations showing frequency shifting of the resonances with implications for electrically small antenna design.

QThA3 • 08:30
Funneling Light Through a Subwavelength Aperture Using Epsilon-Near-Zero Materials, *David Slocum[1], David Adams[1], Sandeep Inampudi[1], Shivashankar Vangala[1], William Goodhue[1], Viktor A. Podolskiy[1], Dan Wasserman[1]; [1]Physics and Applied Physics, Univ. of Massachusetts Lowell, USA.* We demonstrate enhanced light funneling through subwavelength features at optical frequencies using an epsilon near zero (ENZ) material layer. Transmission through a subwavelength slit filled with the epsilon near zero material is characterized.

QThA4 • 08:45
Two-Dimensionally Isotropic High Index Metamaterials, *Yushin Kim[1], Muhan Choi[1,2], Seung Hoon Lee[1], Seung Beom Kang[2], Jonghwa Shin[3], Min Hwan Kwak[2], Kwang-Young Kang[2], Yong-Hee Lee[3], Namkyoo Park[4], Bumki Min[1]; [1]Mechanical Engineering, KAIST, Republic of Korea; [2]ETRI, Republic of Korea; [3]Physics, KAIST, Republic of Korea; [4]Electrical Engineering, Seoul National Univ., Republic of Korea.* We fabricated two-dimensionally isotropic high index metamaterials composed of hexagonal/square metallic ring and demonstrated polarization-insensitive effective refractive indices in the terahertz frequency range.

08:00–09:45 CThA • High-Speed On-Chip Signal Processing

Benjamin Lee, IBM, USA, Presider

CThA1 • 08:00
High-Speed Data Transmission in Multi-Layer Deposited Silicon Photonics for Advanced Photonic Networks-on-Chip, *Aleksandr Biberman[1], Nicolás Sherwood-Droz[2], Xiaoliang Zhu[1], Michal Lipson[2], Keren Bergman[1]; [1]Dept. of Electrical Engineering, Columbia Univ., USA; [2]School of Electrical and Computer Engineering, Cornell Univ., USA.* We introduce a multi-layer silicon photonic microring resonator filter, fabricated using deposited materials, and transmit up to 12.5-Gb/s error-free data, establishing a novel class of high-performance silicon photonics for advanced photonic NoCs.

CThA2 • 08:15
Ultra-compact, slow light enhanced, 160Gbaud de-multiplexing in a silicon photonic crystal waveguide, *Bill Corcoran[1], Mark D. Pelusi[1], Christelle Monat[1], Juntao Li[2], Liam O'Faolain[2], Thomas F. Krauss[2], Benjamin J. Eggleton[1]; [1]CUDOS, IPOS, School of Physics, The Univ. of Sydney, Australia; [2]School of Physics and Astronomy, Univ. of St. Andrews, UK.* We demonstrate error-free demultiplexing of 160Gbit/s optical data to a 10Gbit/s data stream, exploiting slow light enhancement of four-wave mixing in an ultra-compact 96μm long, dispersion engineered silicon photonic crystal waveguide.

CThA3 • 08:30
On-chip optical pulse erasure for ultrahigh bandwidth signal processing, *Ravi Pant[1,3], Trung D. Vo[1,3], Chunle Xiong[1,3], Mark D. Pelusi[1,3], Steve J. Madden[2,3], Barry Luther-Davies[2,3], Ben Eggleton[1,3]; [1]School of Physics, Univ. of Sydney, Australia; [2]Laser Physics Centre, Australian National Univ., Australia; [3]Centre for Ultrahigh bandwidth Devices for Optical Systems, CUDOS, Australia.* We present on-chip, all-optical pulse erasure for enabling ultrahigh-bandwidth signal processing. 15 dB pump depletion is achieved for picoseconds pulses using the instantaneous $\chi^{(3)}$ nonlinearity in a dispersion-engineered chalcogenide waveguide.

CThA4 • 08:45
Time domain switching / demultiplexing using four wave mixing in GaInP photonic crystal waveguides, *Isabelle Cestier[1], Amnon Willinger[1], Vardit Eckhouse[1], Gadi Eisenstein[1], Sylvain Combrié[2], Pierre Colman[2], Gaelle Lehoucq[2], Alfredo De Rossi[2]; [1]EE Dept., Technion, Israel; [2]Thales Research and Development, France.* Dynamical four wave mixing in GaInP photonic crystal waveguides is demonstrated for time domain switching/demultiplexing to extract one out of 16 or 32 channels having an aggregate bit rate of 10.56Gbit/s.

08:00–09:45 QThB • Symposium on The Zeno Effect in Optoelectronics and Quantum Optics I

Edo Waks, Univ. of Maryland, USA, Presider

QThB1 • 08:00 Invited
Zeno or Anti-Zeno : which is more useful? *Gershon Kurizki, Weizmann Inst., Israel.* The quantum Zeno effect (QZE) and its inverse, the anti-Zeno effect (AZE), are complementary paradigms underlying the dynamical control of quantum systems subject to decoherence or mixedness.

QThB2 • 08:30
Quantum Zeno Effect and Quantum Zeno Dynamics in Cavity Quantum Electrodynamics, *Jean-Michel Raimond[1], Clement Sayrin[1], Sebastien Gleyzes[1], Igor Dotsenko[1], Michel Brune[1], Serge Haroche[1], Paolo Facchi[2], Saverio Pascazio[2]; [1]LKB, ENS, UPMC, France; [2]Universita di Bari, Italy.* We describe a cavity QED experiment on quantum Zeno effect with Rydberg atoms and a microwave superconducting cavity. We propose an implementation of quantum Zeno dynamics leading to promising methods for tailoring non-classical field states.

QThB3 • 08:45
Optical 'bistability' with single atom absorbers, *Joseph Kerckhoff[1], Michael A. Armen[1], Dmitri S. Pavlichin[1], Hideo Mabuchi[1]; [1]Edward L. Ginzton Lab, Stanford Univ., USA.* We present observations of macroscopic switching of the optical field transmitted by a saturation-driven, single-atom cavity QED system induced by the atomic scattering of single photons.

08:00–09:45 CThB • Extreme Wavelength Comb Generation

David Jones, Univ. of British Columbia, Canada, Presider

CThB1 • 08:00
High harmonic generation with fs frequency combs and limitations due to intracavity plasma dynamics, *Jason Jones[1], David Carlson[1], Jane Lee[1], Ewan M. Wright[1], John Mongelli[1]; [1]College of Optical Sciences, Univ. of Arizona, USA.* The dynamic intracavity ionization of a dilute gas target can substantially alter the pulse formation inside resonant fs enhancement cavities. We numerically and experimentally study these effects and how they affect intracavity high harmonic generation.

CThB2 • 08:15
High harmonic generation of Ti:S fs pulses using a passive cavity toward state detection of single indium ion, *Tetsuya Ido[1], Kentaro Wakui[1], Kazuhiro Hayasaka[1]; [1]Natinal Inst. of Information and Communictions Technology, Japan.* VUV pulses at 159nm were generated as the 5th high harmonic of passively enhanced Ti:S fs pulses. The average output of 1.5μW might be sufficient to realize direct state detection of an indium ion clock.

CThB3 • 08:30 Invited
Frequency comb metrology in the extreme ultraviolet, *Dominik Z. Kandula[1,2], Christoph Gohle[1,3], Tjeerd J. Pinkert[1], Jonas Morgenweg[1], Itan Barmes[1], Wim Ubachs[1], Kjeld S. Eikema[1]; [1]LaserLaB, FEW, VU Univ., Netherlands; [2]Max Born Inst., Germany; [3]Physics, Ludwig-Maximilians-Univ., Germany.* Frequency comb generation and excitation of argon, neon, and helium is shown from 51 to 85 nm with amplified and harmonically upconverted comb laser pulses, resulting in an 8-fold improved helium ground state ionization energy.

CLEO: Science & Innovations

07:00–18:00 Registration Open, *Baltimore Convention Center, Pratt Street, 300 Level Lobby*

08:00–09:45
CThC • Guided-Wave Optical Sensing

Ulrike Willer, Clausthal Univ. of Technology, Germany, Presider

CThC1 • 08:00
Edge Emitting Sensors for Accurate Quantification of Hydrogen Composition Above 0.5%, *Benjamin G. Griffin[1], Lynford L. Goddard[1]; [1]Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA.* An edge-emitting waveguide laser with an integrated palladium thin film for hydrogen sensing is presented. This device exhibits a 15% increase in the laser output power and 50pm peak wavelength redshift per percent hydrogen.

CThC2 • 08:15
Sensitized Silicon Ring Resonators for the Detection of TNT in the Gas Phase, *Rozalia Orghici[1], Ulrike Willer[2], Peter Lützow[1], Wolfgang Schade[1,2]; [1]Fraunhofer Heinrich Hertz Inst., Germany; [2]Inst. for Energy Research and Physical Technologies, Clausthal Univ. of Technology, Germany.* A silicon ring resonator is coated with receptor molecules for selective enrichment of TNT. Upon intercalation of TNT, changes in effective refractive index lead to a shift in resonance frequency which can accurately be determined.

CThC3 • 08:30
Probing Quantum Dot Cores, Their Interfaces and Thiol Cappings Non-Destructively in Dilute Solution using Raman Scattering in Hollow Core Photonic Crystal Fiber, *Jacky S. W. Mak[1], Abdiaziz A. Farah[1], Feifan Chen[1], Amr S. Helmy[1]; [1]The Edward S. Rogers Sr. Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada.* Efficient Raman scattering of thiol-capped CdTe quantum dot solutions were obtained using HC-PCF. Strong Raman modes of the CdTe core, thiol agents, and their interfacial compound were observed and compared for the first time.

CThC4 • 08:45
Photonic Crystal Slot Waveguide Spectroscopy for the Detection of Chemical Warfare Simulants, *Swapnajit Chakravarty[1], Ray T. Chen[2]; [1]Omega Optics, USA; [2]Electrical and Computer Engineering, Univ. of Texas, USA.* A photonic crystal slot waveguide based infrared absorption spectroscopy device is demonstrated for the on-chip spectroscopic determination of chemical warfare simulant triethylphosphate.

08:00–09:45
CThD • New Wavelength Fiber Lasers

Jihong Geng, AdValue Photonics, USA, Presider

CThD1 • 08:00 Invited
Mid-IR Fiber Lasers Based on Molecular Gas-filled Hollow-Core Photonic Crystal Fiber, *Andrew Jones[1], A. V. Vasudevan Nampoothiri[2], Tobias Fiedler[2], Rajesh Kadel[1], William Hageman[1], Natalie V. Wheeler[3], Francios Couny[3], Fetah Benabid[3], Wolfgang Rudolph[2], Kristan L. Corwin[1], Brian R. Washburn[1]; [1]Kansas State Univ., USA; [2]Dept. of Physics, Univ. of New Mexico, USA; [3]Centre for Photonics and Photonic Materials, Dept. of Physics, Univ. of Bath, UK.* Lasing from HCN gas contained in HC-PCF is observed for the first time. Mid-IR pulses (3.15 and 3.09 μm) were generated by optically pumping at 1.54 μm. A $^{12}C_2H_2$-filled gas laser is also studied quantitatively.

CThD2 • 08:30
Mid-IR Supercontinuum (SC) Generation in ZBLAN fiber pumped by Tm-doped amplifier with fused silica SC input, *Ojas Kulkarni[1], Vinay Alexander[1], Malay Kumar[1], Mohammed N. Islam[1,2], Michael J. Freeman[2], Fred L. Terry[1]; [1]Electrical Engineering and Computer Science, Univ. of Michigan, USA; [2]Omni Sciences Inc., USA.* We demonstrate supercontinuum generation beyond 4.5 μm by first shifting 1.55 μm laser-diode pulses to ~2 μm in standard single-mode fiber followed by amplification using Tm-doped amplifier and subsequent coupling to ~7 m ZBLAN fiber.

CThD3 • 08:45
0.4 mW Average Power at 17.5μm from Frequency Mixing Output of Two-Color Fiber Chirped Pulse Amplifier, *Donna Strickland[1], Mojtaba Hajialamdari[1], Alaa Al-Kadry[1]; [1]Physics and Astronomy, Univ. of Waterloo, Canada.* We have demonstrated the generation of 400 μW of power at ~18 μm by difference-frequency mixing the 1038 and 1105 nm from a two-color, chirped pulse amplification Yb:fibre system.

08:00–09:45
CThE • THz QCLS

Giacomo Scalari, ETH Zurich, Switzerland, Presider

CThE1 • 08:00
A Terahertz Quantum-Cascade Laser with an Active Leaky-Wave Metamaterial Antenna, *Amir A. Tavallaee[1,2], Matthew Puckett[1,2], Benjamin Williams[1,2], Philip Hon[1], Tatsuo Itoh[1], Qi-Sheng Chen[3]; [1]Electrical Engineering, Univ. of California, Los Angeles, USA; [2]California NanoSystems Inst. (CNSI), USA; [3]Aerospace Systems, Northrop Grumman, USA.* A one-dimensional metamaterial waveguide for terahertz quantum-cascade lasers is presented that tailors laser radiation to a low-divergence beam. The demonstrated prototype exhibits narrow (FWHM~15°) surface emission (40° from broadside) at 2.74 THz.

CThE2 • 08:15
Metal-Metal THz Quantum Cascade Laser Gain and Loss Investigated by THz Time Domain Spectroscopy, *Michael Martl[1], Juraj Darmo[1], Christoph Deutsch[1], Martin Brandstetter[1], Alexander Benz[1], Aaron M. Andrews[2], Pavel Klang[3], Werner Schrenk[3], Gottfried Strasser[2], Karl Unterrainer[1,3]; [1]Photonics Inst., Vienna Univ. of Technology, Austria; [2]Inst. of Solid State Electronics, Vienna Univ. of Technology, Austria; [3]Center for Micro- an Nanostructures, Vienna Univ. of Technology, Austria.* THz time-domain studies on metal-metal THz quantum cascade lasers are presented. A coupled cavity method allows to probe the laser via modulation of coherent broadband THz pulses. Observed laser gain and loss processes are discussed.

CThE3 • 08:30
Active photonic crystal terahertz laser operating in higher bands, *Alexander Benz[1], Christoph Deutsch[1], Martin Brandstetter[1], Karl Unterrainer[1], Aaron M. Andrews[1], Pavel Klang[1], Hermann Detz[1], Werner Schrenk[1], Gottfried Strasser[1]; [1]Vienna Univ. of Technology, Austria.* We present the design, fabrication and characterization of active photonic crystals terahertz quantum-cascade lasers operating in higher photonic bands. The upper bands lead to a large tuning range during operation.

CThE4 • 08:45
True Phase-Matched Third-order DFB Terahertz Quantum-Cascade Lasers using Weakly-coupled Cavities, *Tsung-Yu Kao[1], Qing Hu[1], John Reno[2]; [1]Electrical Engineering, MIT, USA; [2]Center of Integrated Nanotechnologies, Sandia National Laboratories, USA.* A novel laser cavity design in third-order DFB THz QCLs based on true phase-matching technique is demonstrated. It increases the usable numbers of third-order DFB grating to 150 (5.6-mm long device) and achieve 6 deg beam divergence.

07:00–18:00 Registration Open, *Baltimore Convention Center, Pratt Street, 300 Level Lobby*

08:00–09:45 QThC • Fundamentals of Nano-Optics and Plasmonics

David Woolf, Harvard Univ., USA, Presider

QThC1 • 08:00
The Role of Kinetic Inductance in Metal Optics, *Matteo Staffaroni[1], Eli Yablonovitch[1]; [1]UC Berkeley EECS Dept., USA.* A simple LC circuit model recovers the surface plasmon dispersion relation. The model clearly reveals the role of kinetic inductance in shaping the dispersion and other key properties of surface plasmons.

QThC2 • 08:15
Plasmonic Properties of Metallic Nanoparticles: The Effects of Size Quantization, *Emily Townsend[1], Garnett W. Bryant[1]; [1]Joint Quantum Inst., National Inst. of Standards & Technology and Univ. of Maryland, USA.* We examine the quantum mechanics of plasmons in metallic nanoparticle systems using time-dependent density functional theory. We identify "quantum core plasmons" and "classical surface plasmons".

QThC3 • 08:30
Organic materials with negative and controllable electric permittivity, *Guohua Zhu[1], Lei Gu[1], John Kitur[1], Augustine Urbas[2], Jarrett Vella[2], Mikhail Noginov[1]; [1]Norfolk State Univ., USA; [2]Air Force Research Lab, USA.* We show that metal-free materials with negative real parts of the electric permittivity can be realized experimentally and their dielectric functions can be controlled by laser illumination.

QThC4 • 08:45
Photon Drag Effect in Nanostructured Plasmonic Films, *Andrey Yakim[1], Natalia Noginova[1], Yuri Barnakov[1]; [1]Center for Materials Research (CMR), Norfolk State Univ., USA.* Strong enhancement of the photon drag effect due to nanostructuring of the surface has been demonstrated in thin metal films.

08:00–09:45 CThF • Nonlinear Microscopy

Tomasz Tkaczyk, Rice Univ., USA, Presider

CThF1 • 08:00
Remote Focusing Differential Multiphoton Microscopy: Application to Neuronal Imaging, *Erich E. Hoover[1], Michael D. Young[1], Susy M. Kim[2], Eric V. Chandler[1], Jeffrey J. Field[1], Dawn N. Vitek[1], Kraig E. Sheetz[3], Jing W. Wang[2], Jeff A. Squier[1]; [1]Physics, Colorado School of Mines, USA; [2]Biological Sciences, Univ. of California-San Diego, USA; [3]Physics and Nuclear Engineering, United States Military Academy, USA.* We apply remote focusing to multi-focal multiphoton microscopy by simultaneously imaging multiple focal planes of *Drosophila melanogaster* olfactory neurons. This technology permits imaging the entire volume of the antennal lobe in a single scan.

CThF2 • 08:15
Controlled Spatiotemporal Focusing Through Turbid Media, *Ori Katz[1], Yaron Bromberg[1], Eran Small[1], Yaron Silberberg[1]; [1]Physics of Complex Systems, Weizmann Inst. of Science, Israel.* We apply adaptive beam shaping for spatiotemporal focusing of ultrashort pulses through turbid media, in the context of nonlinear microscopy. We find that controlled temporal shaping is attainable using only the spatial degrees of control.

CThF3 • 08:30
***In vivo* Imaging Using Second-Harmonic Nanoparticles**, *Chia-Lung Hsieh[1,2], Thomas Lanvin[1], Rachel Grange[1], Ye Pu[1], Demetri Psaltis[1]; [1]School of Engineering, EPFL, Switzerland; [2]Electrical Engineering, Caltech, USA.* We demonstrate second-harmonic nanoparticles as nanoprobes for long-term and in vivo imaging. The nanoparticles emitted a stable signal over five-hour continuous excitation and showed great contrast in a living mouse tail at 100 μm depth.

CThF4 • 08:45
High-Speed Second Harmonic Generation Holographic Microscopy, *Omid Masihzadeh[1], Philip Schlup[1], Randy Bartels[1,2]; [1]Electrical and Computer Engineering, Colorado State Univ., USA; [2]School of Biomedical Engineering, Colorado State Univ., USA.* We present three-dimensional images of biological samples using nonlinear optical, holographic microscopy. The femtosecond oscillator operates at a wavelength with low scattering in the sample and low average power prevents damage to the samples.

08:00–09:45 CThG • Mode-Locked Lasers

Stephane Calvez, Univ. of Strathclyde, UK, Presider

CThG1 • 08:00
High-power spectral bistability in a multi-section quantum dot laser under continuous-wave or mode-locked operation, *Daniil I. Nikitichev[1], Maria Ana Cataluna[1], Ying Ding[1], Ksenia A. Federova[1], Igor Krestnikov[2], Daniil A. Livshits[2], Edik U. Rafailov[1]; [1]Electronic Engineering and Physics, Univ. of Dundee, UK; [2]Innolume GmbH, Germany.* Wavelength bistability between 1245nm and 1295nm is demonstrated in a multi-section quantum-dot laser, controlled via the reverse bias on the saturable absorber. Continuous-wave or mode-locked regimes are achieved (output power up to 25mW and 17mW).

CThG2 • 08:15
Two-section InAs/InP Quantum-Dash Passively Mode Locked Lasers, *Ricardo Rosales[1], Kamel Merghem[1], Anthony Martinez[1], Alain Accard[2], Francois Lelarge[2], Abderrahim Ramdane[1]; [1]Lab for Photonics and Nanostructures, CNRS, France; [2]Alcatel-Thales III-V Lab, joint lab of "Bell labs" and "Thales Research & Technology", France.* First observations of 2-section InAs/InP quantum-dash passive mode locking at 48 GHz are presented. Mode locking trends are compared to those of a 1-section device and to the ones reported for InAs/GaAs quantum-dot lasers.

CThG3 • 08:30 Invited
Femtosecond Semiconductor Lasers, *Anne Tropper[1]; [1]Physics and Astronomy, Univ. of Southampton, UK.* Passive modelocking of surface-emitting semiconductor quantum well lasers can generate transform-limited optical pulses with duration comparable to the carrier-carrier scattering time. This presentation reviews recent advances in this field.

08:00–09:45 CThH • Coherent Systems

David Caplan, MIT Lincoln Lab, USA, Presider

CThH1 • 08:00
Bandwidth Scalable, Coherent Transmitter Based on Parallel Spectral Slice Waveform Generation, *David J. Geisler[1], Nicolas K. Fontaine[1], Ryan P. Scott[1], Tingting He[1], Loukas Paraschis[2], Ori Gerstel[2], Jonathan P. Heritage[1], S. J. Ben Yoo[1]; [1]Electrical and Computer Engineering, Univ. of California, Davis, USA; [2]Cisco Systems, USA.* We present a bandwidth scalable optical transmitter for creating high bandwidth optical signals using parallel low speed electronics. Proof-of-concept 20 GHz spectral width, 100 ns, 10 Gb/s DPSK and 20 Gb/s QPSK waveforms are generated.

CThH2 • 08:15
Analyses of Polarization-Multiplexed WDM Transmission Characteristics of High-Order Optical QAM Signals, *Kazuro Kikuchi[1]; [1]Univ. of Tokyo, Japan.* We analyze optical transmission characteristics of polarization-multiplexed WDM signals using 64-QAM and 256-QAM formats at 12.5 Gsymbol/s. XPM between WDM channels and two polarization tributaries limit the transmission distance below 1,000 km.

CThH3 • 08:30
8×400-Gbit/s PDM-QPSK with 100 GHz Channel Spacing Over 2000km Transmission Using MAP Detection, *Junyi Wang[1], Xuan He[1], Kailu Gao[1], Longston Myers[1], Chongjin Xie[2], Zhongqi Pan[1]; [1]EECE, Univ. of Louisiana at Lafayette, USA; [2]Bell labs, Alcatel-Lucent, USA.* We simulated 8×400-Gbit/s PDM-QPSK over 2000-km transmission by using Map detection to reduce the channel spacing to 100-GHz. MAP detection can significantly improve the system performance to $< 10^{hA5}$ BER compared to non-MAP detection.

CThH4 • 08:45
Experimental Optical Multiplexing of Two 20-Gbit/s QPSK Data Channels from Different Wavelengths onto a Single 40-Gbit/s Star 16-QAM using Fiber Nonlinearities, *Xiaoxia Wu[1], Jian Wang[1], Hao Huang[1], Alan E. Willner[1]; [1]USC, USA.* We experimentally demonstrate optical multiplexing of two 20-Gbit/s QPSK data channels at different wavelengths onto a single 40-Gbit/s star 16-QAM channel with tunable ring ratio using two cascaded fiber-based nonlinear stages.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

07:00–18:00 Registration Open, *Baltimore Convention Center, Pratt Street, 300 Level Lobby*

08:00–09:45 QThD • Discrete Optics and Periodic Structures

Zhigang Chen, San Francisco State Univ., USA, Presider

QThD1 • 08:00
Optical tachyons, broken PT-symmetry, and strain effects in photonic grapheme, *Alexander Szameit[1], Mikael C. Rechtsman[1], Omri Bahat-Treidel[1], Moti Segev[1]; [1]Physics, Technion, Israel.* We demonstrate that optical tachyons, particles that travel faster than the speed of light, can be generated by PT-symmetry breaking in photonic graphene. We further show that the PT-symmetry can be restored via strain.

QThD2 • 08:15
New Physics of Subwavelength High Contrast Gratings, *Vadim Karagodsky[1], Forrest Sedgwick[1], Connie J. Chang-Hasnain[1]; [1]Dept. of Electrical Engineering and Computer Sciences, Univ. of California, Berkeley, USA.* We present a simple yet precise theory, which explains the two main extraordinary features of optical gratings in the near-subwavelength regime: namely broadband high (>99%) reflectivity and ultra-high quality factor (Q~2x10^5) resonances.

QThD3 • 08:30
Notch Nonlinear Frequency Shift in AlGaAs Bragg Grating Waveguides, *Matteo Clerici[1], Marco Peccianti[1,2], Michael J. Strain[3], Pamela Tannouri[1], Alessia Pasquazi[1], Sze Phing Ho[1,4], Ian Rowe[1], Katarzyna A. Rutkowska[5], Marc Sorel[3], Roberto Morandotti[1]; [1]Énergie, Matériaux et Télécommunications, INRS, Canada; [2]IPCF-CNR and UOS, Univ. "Sapienza", Italy; [3]School of Engineering, Univ. of Glasgow, UK; [4]Nanophotonics Research Alliance, Universiti Teknologi Malaysia, Malaysia; [5]Faculty of Physics, Warsaw Univ. of Technology, Poland.* We present an investigation on the nonlinear dynamics of intense pulses in an AlGaAs Bragg waveguide and we report the experimental observation of an intensity dependent blue-shift of the Bragg notch spectral line.

QThD4 • 08:45
Discrete Solitons in Photonic Lattices with Topological Defects, *Matthias Heinrich[1], Robert Keil[1], Felix Dreisow[1], Andreas Tünnermann[1], Stefan Nolte[1], Alexander Szameit[2,1]; [1]Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [2]Physics Dept. and Solid State Inst., Technion, Israel.* We demonstrate numerically and experimentally how Topological Defects represented by junctions within otherwise periodical planar photonic lattices influences discrete solitons similar to conventional defects constituted by detuned waveguides.

08:00–09:45 QThE • Single Photons: Sources and Detectors

Michael Raymer, Univ. of Oregon, USA, Presider

QThE1 • 08:00
Optical Fibre With Embedded Diamond Nanocrystals: Towards a High Collection Efficiency, Waveguided Single Photon Source, *Matthew R. Henderson[1], Shahraam Afshar V.[1], Andrew D. Greentree[2], Tanya M. Monro[1]; [1]School of Chemistry & Physics, Univ. of Adelaide, Australia; [2]School of Physics, Univ. of Melbourne, Australia.* A model for the capture of diamond colour centre emission by a step-index fibre, including effects due to the fibre core-cladding interface, is presented. We investigate the parameter space for optimal single photon capture.

QThE2 • 08:15
Sub-nanosecond Electro-optic Modulation of Triggered Single Photons from a Quantum Dot, *Matthew T. Rakher[1], Kartik Srinivasan[1]; [1]Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA.* Telecommunications-band single photons from a quantum dot are amplitude modulated on timescales fast compared to its radiative decay. Control of single photon wave-packets is an important resource for developing hybrid quantum systems.

QThE3 • 08:30
Third-Order Antibunching from an Imperfect Single-Photon Source, *Martin J. Stevens[1], Scott Glancy[1], Sae Woo Nam[1], Richard P. Mirin[1]; [1]NIST, USA.* We measure second- and third-order coherences of an imperfect single-photon source. The magnitude of 3rd-order antibunching indicates that imperfect 2nd-order antibunching results from background emission with Poissonian photon number statistics.

QThE4 • 08:45
Multi-wavelength pumping technique for up-conversion single-photon detectors, *Lijun Ma[1], Joshua Bienfang[1], Oliver Slattery[1], Xiao Tang[1]; [1]NIST, USA.* We propose a multi-wavelength pumping technique to improve temporal resolution of up-conversion single-photon detectors. By using two-wavelength pumping we doubled the date rate of a quantum system beyond its original limitation.

08:00–09:45 CThI • Optical Signal Processing

Tetsuya Kawanishi, NICT, Japan, Presider

CThI1 • 08:00 Invited
Demonstration of a 10 GHz CMOS-Compatible Integrated Photonic Analog-to-Digital Converter, *Matthew E. Grein[1], Steven Spector[1], Anatol Khilo[2], Amir H. Najadmalayeri[2], Michelle Y. Sander[2], Michael Peng[2], Jade Wang[1], Cheryl M. Sorace[2], Michael W. Geis[1], Matthew M. Willis[1], Donna M. Lennon[1], Theodore Lyszczarz[1], Erich P. Ippen[2], Franz X. Kaertner[2]; [1]MIT Lincoln Lab, USA; [2]Research Lab of Electronics, Massachusetts Inst. of Technology, USA.* We demonstrate two fully functional channels of a real-time photonic ADC using mostly CMOS-compatible devices to optically sample and electronically digitize a 10-GHz RF signal with 37.9 dB SNR (6.0 ENOB) with a 1 GHz optical pulse train.

CThI2 • 08:30
Photonic Intensity Integrator with Combined High Processing Speed and Long Operation Time Window, *Mohammad H. Asghari[1], Yongwoo Park[1], Jose Azana[1]; [1]EMT, Énergie, Matériaux et Télécommunications (EMT), Canada.* We demonstrate a new design for time integration of microwave and optical intensity signals with unprecedented processing time-bandwidth product (>140), by cascading a discrete-time integrator and high-speed analog time-limited intensity integrator.

CThI3 • 08:45
Low Noise Stabilized Chirped Pulse Theta Laser for Photonic ADC, *Dimitrios Mandridis[1], Charles Williams[1], Ibrahim Ozdur[1], Peter J. Delfyett[1]; [1]CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA.* A semiconductor-based 100 MHz Theta cavity design laser using a fiberized Fabry-Perot etalon with an intra-cavity modified Hänsch-Couillaud scheme is presented. AM noise spectra reveal suppression of the supermode noise spur by >30 dB.

CLEO: QELS-Fundamental Science

QThA • Electro-Magnetic Metamaterials—Continued

QThA5 • 09:00
Highly Confined Hybrid Spoof Surface Plasmons in Ultra-thin Metal/Dielectric Heterostructures, *Hossein Mousavi[1], Alexander Khanikaev[1], Burton Neuner III[1], Yoav Avitzour[1], Dmitriy Korobkin[1], Gabriel Ferro[2], Gennady Shvets[1]; [1]Dept. of Physics, Univ. of Texas at Austin, USA; [2]Laboratoire des Multimatériaux et Interfaces, Université Claude Bernard Lyon 1, France.* Highly confined "spoof" surface plasmons (SSPs) are predicted and observed in a perforated metal film coated with a thin dielectric layer. They are better confined than conventional guided modes and SSPs while controllable by perforations geometry.

QThA6 • 09:15
On-Way Slow Light in Nonreciprocal Low-Symmetry Metamaterials, *Alexander B. Khanikaev[1], Chihhui Wu[1], Hossein Mousavi[1], Gennady Shvets[1]; [1]Physics, The Univ. of Texas at Austin, USA.* It is shown that metamaterials containing magnetooptical media exhibit nonreciprocal (NR) properties ranging from polarization dependent isolation to one-way slow-light. This opens a new avenue to control light and design NR optical elements.

QThA7 • 09:30
Retarded-interaction magnetization waves in planar split-ring-resonator arrays, *Manuel Decker[1], Nils Feth[1], Stefan Linden[1], Martin Wegener[1]; [1]Karlsruhe Inst. of Technology (KIT), Germany.* Resonance damping in split-ring-resonator square arrays operating at 200-THz frequency depends on both lattice constant and observation angle. This behavior is interpreted in terms of magnetization waves with retarded nearest-neighbor interaction.

CLEO: Science & Innovations

CThA • High-Speed On-Chip Signal Processing—Continued

CThA5 • 09:00 Invited
Ultra-fast Optical Signal Processing using Optical Time Lenses and Highly Nonlinear Silicon Nanowires, *Leif K. Oxenloewe; [1]DTU Fotonik, Dept. of Photonic Engineering, Technical Univ. of Denmark, Denmark.* Abstract not available.

CThA6 • 09:30
A Bidirectional SRL with Further Miniaturized RR Structure: Design and Its High-speed All-optical Switching, *Zhuoran Wang[1], Guohui Yuan[1], Xinlun Cai[2], Guy Verschaffelt[3], Jan Danckaert[3], Yong Liu[1], Siyuan Yu[2]; [1]School of Optoelectronic Information, Univ. of Electronic Science and Technology of China, China; [2]Dept. of Electrical and Electronic Engineering, Univ. of Bristol, UK; [3]Dept. of Applied Physics and Photonics, Vrije Universiteit Brussel, Belgium.* A bidirectional SRL device with further miniaturized RR structure is fabricated. The fast switching speed of about 40ps and excellent BER performance indicate that this SRL device can be explored further in high-speed all-optical scenarios.

CLEO: QELS-Fundamental Science

QThB • Symposium on The Zeno Effect in Optoelectronics and Quantum Optics I—Continued

QThB4 • 09:00 Invited
Organic Materials for Zeno-Based Optical Switching, *Joel Hales[1], Jonathon D. Matichak[1], Hsin-Chieh Lin[1], Yanrong Shi[1], Jochen Campo[1], Nikolay Makarov[1], Hyeongeu Kim[1], Sei-Hum Jang[2], Alex K.-Y. Jen[2], Seth R. Marder[1], Joseph W. Perry[1]; [1]School of Chemistry and Biochemistry, Georgia Inst. of Technology, USA; [2]Dept. of Materials Science and Engineering, Univ. of Washington, USA.* Compounds showing strong non-degenerate two-photon absorption hold potential for Zeno-based optical switching schemes. We report on organic compounds including polymethines and squaraines with large non-degenerate two photon cross sections.

QThB5 • 09:30
Quantum Logic Operations Using the Zeno Effect, *James Franson[1], Todd Pittman[1]; [1]Physics Dept., Univ. of Maryland Baltimore County, USA.* Quantum logic operations can be performed using the quantum Zeno effect based on strong two-photon absorption. This approach can be generalized to perform all-optical switching of classical signals.

CLEO: Science & Innovations

CThB • Extreme Wavelength Comb Generation—Continued

CThB4 • 09:00
Intracavity high harmonic generation driven by Yb-fiber based MOPA system at 80MHz repetition rate, *Akira Ozawa[1,2], Yohei Kobayashi[1,2]; [1]Inst. for Solid State Physics, Univ. of Tokyo, Japan; [2]Core Research for Evolutional Science and Technology (CREST), JST, Japan.* Coherent deep-UV radiation is produced by Yb-fiber-laser based cavity-enhanced high-harmonic generation at 80-MHz repetition rate. The intracavity-power exceeds 3kW and up to 17th harmonics are outcoupled by thin Brewster's plate made by MgO crystal.

CThB5 • 09:15
Direct Referencing of a Quantum-Cascade-Laser at 4.3 μm to a Near-Infrared Frequency Comb, *Marco Marangoni[1], Alessio Gambetta[1], Davide Gatti[1], Antonio Castrillo[3], Gianluca Galzerano[2], Paolo Laporta[1,2], Livio Gianfrani[3]; [1]Physics, Politecnico di Milano, Italy; [2]IFN-CNR, Italy; [3]Environmental Sciences, Seconda Università di Napoli, Italy.* A sum-frequency-generation scheme is exploited to refer the frequency of a quantum-cascade-laser at 4.3 μm to a near-IR frequency comb based on a dual-branch Er:fiber laser without interposition of any transfer oscillator.

CThB6 • 09:30
Octave Spanning Supercontinuum in an As_2S_3 Taper using Ultra-low Pump Pulse Energy, *Darren D. Hudson[1], Steven Dekker[1], Eric Mägi[1], Alex Judge[1], Stuart Jackson[1], Enbang Li[1], Jas Sanghera[2], Brandon Shaw[2], Ishwar D. Aggarwal[2], Ben Eggleton[1]; [1]CUDOS, Univ. of Sydney, Australia; [2]Naval Research Lab, USA.* An octave spanning spectrum is generated in an As_2S_3 taper via 77 pJ pulses from an ultrafast fiber laser. Chirp compensation allows the octave to be generated directly from the unamplified laser output.

10:00–10:30 Coffee Break, *Exhibit Halls E and F, 100 Level*

10:00–15:00 Exhibit Hall Hours, *Exhibit Hall, 100 Level*

NOTES

CLEO: Science & Innovations

CThC • Guided-Wave Optical Sensing—Continued

CThC5 • 09:00
Low-cost PCB-integrated Polymer Waveguide Sensor for Gas Detection, *Nikolaos Bamiedakis[1], Tanya Hutter[2], Richard V. Penty[1], Ian H. White[1], Stephen R. Elliott[2]; [1]Engineering Dept., Univ. of Cambridge, UK; [2]Dept. of Chemistry, Univ. of Cambridge, UK.* An optical waveguide sensor formed directly on low-cost PCB substrates is presented for the first time. The device integrates polymer waveguides functionalized with chemical dyes, photonic and electronic components and allows multiple-gas detection.

CThC6 • 09:15
Optical Gain Assisted Far-Field Sub-Wavelength Imaging, *Joshua S. Deaver[1], Weiguo Yang[1], John O. Schenk[2], Michael A. Fiddy[2]; [1]Engineering and Technology, Western Carolina Univ., USA; [2]Center for Optoelectronics and Optical Communications, Univ. of North Carolina at Charlotte, USA.* We propose a far-field sub-wavelength imaging scheme, where evanescent waves from an object are converted to sustainable propagating waves by using optical gain. This approach does not rely on negative refraction, hyper-lenses, or plasmonic effects.

CThC7 • 09:30
Single nanoparticle detection using a microcavity laser, *Lina He[1], Sahin K. Ozdemir[1], Jiangang Zhu[1], Lan Yang[1]; [1]Washington Univ. in St. Louis, USA.* Optical microcavity laser is utilized for label-free detection of single nanoparticles. Detection limit is significantly improved due to the ultra-narrow laser linewidth compared to the resonance linewidth of a passive microcavity.

CThD • New Wavelength Fiber Lasers—Continued

CThD4 • 09:00 Invited
Direct visible lasers by rare earth doped waterproof fluoro-aluminate fibers, *Yasushi Fujimoto[1]; [1]Inst. of Laser Engineering, Japan.* We have successfully drawn rare earth (Pr and Dy) doped waterproof fluoro- aluminate glass fibers at low loss (0.1~0.3 dB/m) and demonstrated visible laser oscillations pumped by a GaN-LD.

CThD5 • 09:30
UV light generation induced by microwave microplasma in hollow-core optical waveguides, *Benoît Debord[1], Raphael Jamier[1], Frédéric Gérôme[1], Caroline Boisse-Laporte[2], Philippe Leprince[2], Olivier Leroy[2], Jean-Marc Blondy[1], Fetah Benabid[1,3]; [1]Xlim research Inst., France; [2]Laboratoire de Physique des Gaz et des Plasmas, France; [3]Centre for Photonics and Photonic Materials, UK.* We experimentally observed for the first time the built up of a microwave microplasma in gas-filled hollow-core waveguides with internal diameter down to 65µm. Ultraviolet wavelengths have been generated and guided directly inside the hollow-core.

CThE • THz QCLS—Continued

CThE5 • 09:00
Gain measurements of a metal-metal terahertz quantum cascade laser using an integrated terahertz pulse emitter, *David P. Burghoff[1], Tsung-Yu Kao[1], Dayan Ban[2,1], Alan Lee[1], John Reno[3], Qing Hu[1]; [1]Dept. of Electrical Engineering and Computer Science, Massachusetts Inst. of Technology, USA; [2]Dept. of Electrical and Computer Engineering, Univ. of Waterloo, Canada; [3]Sandia National Laboratories, USA.* A terahertz pulse emitter is fabricated alongside a quantum cascade laser with a metal-metal waveguide. Terahertz pulses are used to measure the gain of the laser ridge, which is clamped above threshold to 18 cm^{-1}.

CThE6 • 09:15
Vertical Sub-Wavelength Mode Confinement in THz Quantum Cascade Lasers, *Elodie Strupiechonski[1], Davide Grassani[1], Daivid Fowler[1], François H. Julien[1], Raffaele Colombelli[1], Suraj P. Khanna[2], Lianhe Li[2], Edmund H. Linfield[2], Giles A. Davies[2], Andrey B. Krysa[3]; [1]IEF, CNRS, Université Paris- Sud 11, France; [2]SEEE, Univ. of Leeds, UK; [3]Electronic and Electrical Engineering, EPSRC National Center for III-V Technologies, Univ. of Sheffield, UK.* We reduce thickness of the active cores in THz/mid-infrared quantum-cascade lasers. Devices with active regions 60 times thinner than free-space emission wavelength are demonstrated with surprisingly modest increase in threshold current density.

CThE7 • 09:30
Fast tuning of MEMS-based tunable terahertz wire lasers, *Qi Qin[1], Qing Hu[1], John Reno[2]; [1]Dept. of Electrical Engineering and Computer Science and Research Lab of Electronics, MIT, USA; [2]Center of Integrated Nanotechnologies, Sandia National Laboratories, USA.* We demonstrate a fast frequency tuning of terahertz wire-lasers. Using a piezo-actuator and a MEMS-plunger enables a tuning speed up to ~15KHz. Improved bonding-pad of wire-lasers leads to larger fabrication yield and better mode discrimination.

10:00–10:30 Coffee Break, *Exhibit Halls E and F, 100 Level*

10:00–15:00 Exhibit Hall Hours, *Exhibit Hall, 100 Level*

NOTES

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

QThC • Fundamentals of Nano-Optics and Plasmonics—Continued

QThC5 • 09:00
Temporal Coupled-Mode Theory for Resonant Apertures, *Lieven Verslegers[1], Zongfu Yu[1], Peter B. Catrysse[1], Zhichao Ruan[1], Shanhui Fan[1]; [1]Electrical Engineering, Stanford Univ., USA.* We develop the coupled-mode theory for resonant apertures. We show that the maximum transmission and absorption cross sections for resonant apertures are only related to the wavelength and the directivity of the aperture's radiation pattern.

QThC6 • 09:15
Wood's anomaly in arrays of highly anisotropic plasmonic antennas, *Paul W. Kolb[1], Timothy D. Corrigan[5], Howard D. Drew[2,3], Ray J. Phaneuf[3,4], Hossein Mousavi[6], Alexander Khanikaev[6], Gennady Shvets[6]; [1]Lab for Physical Sciences, USA; [2]Physics, Univ. of Maryland, USA; [3]Center for Nanoscale and Advanced Materials, Univ. of Maryland, USA; [4]Materials Science and Engineering, Univ. of Maryland, USA; [5]Physical Sciences, Concord Univ., USA; [6]Physics, The Univ. of Texas, USA.* We examine the Wood's anomaly in arrays of nanorod pairs and find an apparent strong coupling between longitudinal plasmon modes and an oscillating dipole moment perpendicular to the plane of the substrate.

QThC7 • 09:30
Super-resolution via Enhanced Evanescent Tunneling, *Alessandro Salandrino[1], Demetrios Christodoulides[1]; [1]CREOL, Univ. of Central Florida, USA.* We propose the concept of enhanced evanescent tunneling. We show that this process can be used to probe both the amplitude and phase of the evanescent portion of the angular spectrum, thereby allowing target superresolution.

CThF • Nonlinear Microscopy—Continued

CThF5 • 09:00
Subharmonic Synchronization of Picosecond Lasers for Stimulated Raman Scattering Microscopy, *Wataru Umemura[1], Yasuyuki Ozeki[1,2], Kenta Fujita[1], Kiichi Fukui[3], Kazuyoshi Itoh[1]; [1]Dept. of Material and Life Science, Osaka Univ., Japan; [2]JST-PRESTO, Japan; [3]Dept. of Biotechnology, Osaka Univ., Japan.* A 38-MHz picosecond Yb-fiber laser is successfully synchronized to a 76-MHz picosecond Ti:sapphire laser with electronic phase comparators and an intra-cavity electro-optic modulator for high-contrast, label-free imaging with stimulated Raman scattering.

CThF6 • 09:15
Coherent anti-Stokes Raman scattering (CARS) holographic biological imaging, *Perry Edwards[1], Kebin Shi[1], Jing Hu[2], Qian Xu[1], Yanming Wang[2], Demetri Psaltis[3], Zhiwen Liu[1]; [1]Electrical Engineering, the Pennsylvania State Univ., USA; [2]Biochemistry and Molecular Biology, the Pennsylvania State Univ., USA; [3]School of Engineering, Ecole Polytechnique Fédérale de Lausanne, Switzerland.* We demonstrate non-scanning three-dimensional (3D) imaging of cellular components in live cancerous (HeLa) cells by combining the chemical selectivity of CARS with the 3-D imaging capability of holography to establish a new technique for bio-imaging.

CThF7 • 09:30
In-line holographic CARS microscopy, *Qian Xu[1], Kebin Shi[1], Haifeng Li[1], Kerkil Choi[2], Ryoichi Horisaki[2], David Brady[2], Demetri Psaltis[3], Zhiwen Liu[1]; [1]Electrical Engineering, The Pennsylvania State Univ., USA; [2]Electrical and Computer Engineering, Duke Univ., USA; [3]School of Engineering, Ecole Polytechnique Fédérale de Lausanne, Switzerland.* We investigated inline holographic CARS microscopy, in which the reference generated from a nonlinear medium co-propagates with the CARS signal produced from a specimen. We show that this technique has 3D chemical selective imaging capability.

CThG • Mode-Locked Lasers—Continued

CThG4 • 09:00
Femtosecond VECSELs with up to 1-W Average Output Power, *Oliver D. Sieber[1], Martin Hoffmann[1], Valentin J. Wittwer[1], Wolfgang P. Pallmann[1], Igor Krestnikov[2], Sergey S. Mikhrin[2], Daniil A. Livshits[2], Matthias Golling[1], Yohan Barbarin[1], Thomas Südmeyer[1], Ursula Keller[1]; [1]IQE / ULP, ETH Zürich, Switzerland; [2]Innolume GmbH, Germany.* We developed novel low-dispersion VECSELs modelocked with fast QD-SESAMs. The first femtosecond modelocked QD-VECSEL achieves 1 W average power with 784-fs pulses. At lower power, we achieved sub-500-fs pulses both with QW- and QD-VECSELs.

CThG5 • 09:15
10-GHz MIXSEL: An Integrated Ultrafast Semiconductor Disk Laser with 2.2 W Average Power, *Valentin J. Wittwer[1], Benjamin Rudin[1], Deran J.H.C. Maas[1], Martin Hoffmann[1], Oliver D. Sieber[1], Yohan Barbarin[1], Matthias Golling[1], Thomas Südmeyer[1], Ursula Keller[1]; [1]D-PHYS/IQE, ETH Zurich, Switzerland.* We present a 10-GHz Modelocked Integrated External-Cavity Surface Emitting Laser (MIXSEL) with 2.2 W average power in 21-ps pulses, which is the highest power level from any 10-GHz modelocked semiconductor laser.

CThG6 • 09:30
Passive mode locking of discrete mode laser diodes, *David Bitauld[1], Simon Osborne[1], Stephen O'Brien[1]; [1]Tyndall National Inst., Ireland.* We demonstrate low timing jitter 100 GHz passive mode-locking of a discrete mode (DM) laser. This Fabry-Perot device incorporates a spatially varying effective index selecting modes. Near Fourier limited 2.5 ps pulses were obtained.

CThH • Coherent Systems—Continued

CThH5 • 09:00
Optical 8PSK Transmitter using Tandem IQ Modulators with Binary Driving Electrical Signals, *Guo-Wei Lu[1], Takahide Sakamoto[1], Tetsuya Kawanishi[1]; [1]NICT, Japan, Japan.* We propose and demonstrate an optical 8-ary phase-shift keying transmitter using tandem in-phase/quadrature modulators. A 30-Gb/s 8PSK is successfully generated through cascading a rectangular quadrature phase-shift keying (QPSK) and a square QPSK.

CThH6 • 09:15
Crosstalk-Induced OSNR Penalty Prediction on 112 Gb/s PolMux-QPSK System, *Yu-Ting Hsueh[1], Andrew Stark[1], Mark Filer[2], Thomas Detwiler[1], Sorin Tibuleac[2], Gee-Kung Chang[1], Stephen Ralph[1]; [1]Georgia Inst. of Technology, USA; [2]ADVA Optical Networking, USA.* Penalties from in-band crosstalk for 112 Gb/s PolMux-QPSK systems are shown to be readily determined by use of a spectrally weighted crosstalk. Experimental results demonstrate that the method is robust for linear and nonlinear regimes.

CThH7 • 09:30
Frequency-Domain Adaptive Equalization in Digital Coherent Receivers, *Md. S. Faruk[1], Kazuro Kikuchi[1]; [1]Electrical Engineering and Information Systems, The Univ. of Tokyo, Japan.* Aiming at the reduction of computational complexity of conventional time-domain equalizers in digital coherent receivers, we propose and demonstrate a novel frequency-domain adaptive equalization technique based on the constant-modulus algorithm.

10:00–10:30 Coffee Break, *Exhibit Halls E and F, 100 Level*

10:00–15:00 Exhibit Hall Hours, *Exhibit Hall, 100 Level*

NOTES

CLEO: QELS-Fundamental Science

QThD • Discrete Optics and Periodic Structures—Continued

QThD5 • 09:00
Diverging Rabi Oscillations in Sub-wavelength Photonic Lattices, *Barak Alfassi[1], Or Peleg[1], Nimrod Moiseyev[1], Mordechai Segev[1]; [1]Physics, Technion, Israel.* We show that Rabi oscillations between Bloch-modes of an waveguide array with sub-wavelength periodicity diverge, in both frequency and field amplitude, when the optical wavelength approaches a mathematical exceptional point.

QThD6 • 09:15
Anderson localization in optical waveguide arrays with off-diagonal coupling disorder, *Lane Martin[1], Giovanni Di Giuseppe[1,2], Armando Perez-Leija[1,3], Robert Keil[4], Alexander Szameit[5], Ayman Abouraddy[1], Demetrios Christodoulides[1], Bahaa E. Saleh[1]; [1]CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA; [2]School of Science and Technology, Physics Division, Univ. of Camerino, Italy; [3]INAOE, Coordinacion de Optica, Mexico; [4]Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [5]Solid State Inst. and Physics Dept., Technion, Israel.* We observe the transition from extended to Anderson-localized states in silica waveguide arrays exhibiting off-diagonal coupling disorder.

QThD7 • 09:30
Observation of Glauber-Fock dynamics in photonic lattices, *Armando Perez-Leija[1,2], Robert Keil[3], Hector Moya-Cessa[1], Demetrios Christodoulides[1], Alexander Szameit[4]; [1]CREOL, USA; [2]Friedrich-Schiller-Universität, Germany; [3]Optica, INAOE, Mexico; [4]Solid State Inst. and Physics Dept., Technion, Israel.* We report the first observation of classical intensity distributions in optical arrays that are totally analogous to quantum coherent and displaced Fock states. Bloch-like oscillations and revivals are also predicted in such photonic lattices.

QThE • Single Photons: Sources and Detectors—Continued

QThE5 • 09:00
Accessing Photon Bunching with Photon Number Resolving Multi-Pixel Detector, *Leonid Krivitsky[1], Dmitry Kalashnikov[1], Maria Chekhova[2,3]; [1]Data Storage Inst., Singapore; [2]M. V. Lomonosov Moscow State Univ., Russian Federation; [3]Max-Planck Inst. for the Science of Light, Germany.* The intensity correlation function of squeezed vacuum, produced in an OPA, was measured with a photon-number resolving multi-pixel detector (MPPC). Based on realistic MPPC model, strong photon bunching was revealed for low-gain OPA radiation.

QThE6 • 09:15
Full-Field Quantum Correlations with Multi-Pixel Detectors, *Ryan E. Warburton[1], Jonathan Leach[2], David G. Ireland[2], Frauke Izdebski[1], Miles J. Padgett[2], Gerald S. Buller[1]; [1]Engineering and Physical Sciences, Heriot-Watt Univ., UK; [2]Physics & Astronomy, Univ. of Glasgow, UK.* Using multi-pixel detectors, we demonstrate strong full-field quantum correlations in the position and momentum bases. Spatial light modulators used as tunable lenses enabled the observation of correlations in various superpositions of these bases.

QThE7 • 09:30
Cavity-Enhanced Nanowire Superconducting Single Photon Detectors on GaAs, *Alessandro Gaggero[1], Saeedeh Jahanmiri Nejad[2], Francesco Marsili[2], Francesco Mattioli[1], Roberto Leoni[1], David Bitauld[2], Dondu Sahin[2], G. H. Hamhuis[2], Richard Noetzel[2], Rosendo Sanjines[3], Andrea Fiore[2]; [1]Inst. for photonics and nanotechnologies (IFN), Consiglio Nazionale delle Ricerche (CNR), Italy; [2]COBRA Research Inst., Eindhoven Univ. of Technology, Netherlands; [3]Inst. of Condensed Matter Physics (IPMC), Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland.* We report on efficient nanowire NbN superconducting single photon detectors (SSPDs), integrated with an optical cavity based GaAs/AlAs distributed Bragg reflectors, showing a detection efficiency of 18.3% at 4.2K at 1.3 μm wavelength.

CLEO: Science & Innovations

CThI • Optical Signal Processing—Continued

CThI4 • 09:00
Multitap Microwave Photonic Phase Filters, *Ehsan Hamidi[1], Minhyup Song[1], Rui Wu[1], V.r. Supradeepa[1], Christopher M. Long[1], Daniel E. Leaird[1], Andrew M. Weiner[1]; [1]Purdue Univ., USA.* We demonstrate multitap microwave photonic filter with complex tap weights as a programmable spectral phase filter based on single-sideband modulation of an optical frequency comb, and line-by-line optical pulse shaping in an interferometeric scheme.

CThI5 • 09:15
Flat-Top Microwave Photonic Filter Based on Optical Frequency Comb Shaping, *Minhyup Song[1], Christopher M. Long[1], Ehsan Hamidi[1], Rui Wu[1], Venkata Supradeepa[1], Dongsun Seo[1], Daniel E. Leaird[1], Andrew M. Weiner[1]; [1]School of Electrical and Computer Engineering, Purdue Univ., USA.* We present flat-top microwave photonic filters through amplitude and phase shaping of optical frequency combs. Flat-topped filters with greater than 27-dB stopband loss are demonstrated using 32 taps with both positive and negative tap coefficients.

CThI6 • 09:30
A 16-fs aperture-jitter photonic ADC: 7.0 ENOB at 40 GHz, *Amir H. Nejadmalayeri[1], Matthew E. Grein[2], Anatol Khilo[1], Jade Wang[2], Michelle Y. Sander[1], Michael Peng[1], Cheryl M. Sorace[1], Erich P. Ippen[1], Franz X. Kaertner[1]; [1]RLE, MIT, USA; [2]MIT Lincoln Lab, USA.* A photonic ADC based on balanced detection, phase encoded optical sampling, wavelength multiplexing, and electronic quantization is demonstrated. It achieves 7.0 ENOB resolution at a 2GSa/s sub-sampling rate for a 40 GHz input analog signal.

10:00–10:30 Coffee Break, *Exhibit Halls E and F, 100 Level*

10:00–15:00 Exhibit Hall Hours, *Exhibit Hall, 100 Level*

NOTES

CLEO: QELS-Fundamental Science

10:30–12:15
QThF • Disordered Material
Meir Orenstein, Technion Israel Inst. of Technology, Israel, Presider

QThF1 • 10:30
Fabrication and characterization of 3D deterministic aperiodic structures, *Michael Renner[1,2], Martin Wegener[2], Georg von Freymann[1,2]; [1]Fachbereich Physik, Universität Kaiserslautern, Germany; [2]Institut für Nanotechnologie and DFG Center for Functional Nanostructures, Karlsruher Inst. of Technology, Germany.* We present the realization of photonic structures based on the 3D generalization of deterministic aperiodic sequences in a positive photo-resist by direct laser writing. Diffraction patterns are studied showing characteristic intensity distribution.

QThF2 • 10:45
Hyper-Transport of Light by Virtue of Disorder, *Liad Levi[1], Yevgeny Krivolapov[1], Moti Segev[1], Shmuel Fishman[1]; [1]Physics, Technion-Israel Inst. of Technology, Israel.* We demonstrate experimentally that when a spatially-random potential exhibits fast fluctuations also during propagation direction, transport becomes faster than ballistic. This new concept has major implications on transport of quantum particles.

QThF3 • 11:00
Anderson delocalization in one dimensional μ or ε-near-zero metamaterial stacks and other dispersion effects on localization, *Ara A. Asatryan[1], Lindsay C. Botten[1], Michael A. Byrne[1], Valentin D. Freilikher[2], Sergey Gredeskul[3,4], Ilya V. Shadrivov[4], Ross C. McPhedran[5], Yurii A. Kivshar[4,6]; [1]Mathematical Sciences, Univ. of Technology Sydney, Australia; [2]Dept. of Physics, Bar-Ilan Univ., Israel; [3]Dept. of Physics, Ben Gurion Univ. of the Negev, Israel; [4]Nonlinear Physics Center, Australian National Univ., Australia; [5]School of Physics, Univ. of Sydney, Sydney, Australia; [6]St.Petersburg State Univ. of Information Technologies, Mechanics and Optics, Russian Federation.* We have carried out a comprehensive study of dispersion and absorption effects on Anderson localization in one-dimensional metamaterial stacks and have shown that the field is delocalized in μ or ε-near-zero media at normal incidence.

QThF4 • 11:15
Eigenmodes in a randomly disordered medium, *Wonjun Choi[1], Allard P. Mosk[2], Q-Han Park[1], Wonshik Choi[1]; [1]Dept. of Physics, Korea Univ., Republic of Korea; [2]Complex Photonic Systems, Faculty of Science and Technology, and MESAb Inst. for Nanotechnology, Univ. of Twente, Netherlands.* We numerically observe that open eigenmodes enhance the energy stored inside disordered media and prove that eigenmodes contribute to a single-channel optimizing mode, which is realized in recent experiments, in proportion to their eigenvalues.

CLEO: Science & Innovations

10:30–12:15
CThJ • Optomechanics I
Milos Popovic, Univ. of Colorado at Boulder, USA, Presider

CThJ1 • 10:30
Electromagnetically Induced Transparency and Slow Light with optomechanics, *Amir H. Safavi-Naeini[1], Thiago P. Mayer Alegre[1], Jasper Chan[1], Matt Eichenfield[1], Martin Winger[1], Jeffrey T. Hill[1], Qiang Lin[1], Darrick Chang[1], Oskar Painter[1]; [1]Caltech, USA.* We demonstrate electromagnetically induced transparency and slow light in an optomechanical cavity, at cryogenic and ambient conditions, and show effects analogous to electromagnetically induced absorption.

CThJ2 • 10:45
Cavity optomechanical sensors for atomic force microscopy, *Kartik Srinivasan[1], Houxun Miao[1,2], Matthew Rakher[1], Marcelo Davanco[1,2], Vladimir Aksyuk[1,3]; [1]Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA; [2]Maryland Nanocenter, Univ. of Maryland, USA; [3]Dept. of Electrical and Computer Engineering, Univ. of Maryland, USA.* We develop a Si cavity optomechanical sensor for atomic force microscopy through near-field coupling between a nanocantilever and microdisk cavity. The device exhibits sub-fm/√Hz displacement sensitivity, GHz bandwidth, and >60 dB of dynamic range.

CThJ3 • 11:00
Mechanical Trapping in a Quadratically Coupled Optomechanical Double Disk, *Jeffrey T. Hill[1], Qiang Lin[1], Jessie Rosenberg[1], Oskar Painter[1]; [1]Applied Physics, Caltech, USA.* We demonstrate a novel approach for trapping mechanical motion and elastic tuning of mechanical rigidity while preserving phonon number, through a giant quadratic optomechanical coupling created from a tunable coupled microdisk resonator.

CThJ4 • 11:15
Tunable 2D Photonic Crystal Cavities for Cavity Electro-Optomechanics, *Martin Winger[1], Thiago P. Mayer Alegre[1], Amir H. Safavi-Naeini[1], Oskar Painter[1]; [1]Thomas J. Watson, Sr., Lab of Applied Physics, California Inst. of Technology, USA.* We present and demonstrate a novel electro-optomechanical structure based on a slotted waveguide photonic-crystal cavity, in which electrostatics and optics couple simultaneously to the same "phonon" resonance.

CLEO: QELS-Fundamental Science

10:30–12:00
QThG • Symposium on The Zeno Effect in Optoelectronics and Quantum Optics II
Joseph Altepeter, Northwestern Univ., USA, Presider

QThG1 • 10:30
Zeno All-Optical Switching in a Silicon Ring Resonator using Inverse Raman Scattering, *Henry Wen[1], Onur Kuzucu[1], Nicolás Sherwood-Droz[2], Taige Hou[2], Michal Lipson[2,3], Alexander L. Gaeta[1]; [1]Applied and Engineering Physics, Cornell Univ., USA; [2]Electrical & Computer Engineering, Cornell Univ., USA; [3]Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA.* We experimentally demonstrate all-optical control of a single resonance in a silicon micro-ring resonator using Raman-induced loss. Simulations indicate the potential for signal routing with >97% throughput using picojoule control pulses.

QThG2 • 10:45
All-optical switching in SU-8 conductor-gap-dielectric plasmonic microring resonator using thermal nonlinearity, *David Perron[1], Marcelo Wu[1], Cameron Horvath[1], Daniel Bachman[1], Vien Van[1]; [1]Electrical Engineering, Univ. of Alberta, Canada.* Efficient light-to-heat conversion due to ohmic loss in a Au/SiO_2/SU-8 plasmonic microring resonator was exploited to achieve all-optical switching. We obtained 20 times larger resonance shift in the resonator over similar SU-8 dielectric microrings.

QThG3 • 11:00 Invited
Nonlinear optics near the single photon level with quantum dots, *Edo Waks[1], Deepak Sridharan[1], Ranojoy Bose[1], Hyochul Kim[1], Glenn Solomon[2]; [1]Electrical and Computer Engineering, Univ. of Maryland, USA; [2]Physics, National Inst. of Science and Technology, USA.* We describe our work on engineering nonlinear optical devices using quantum dots coupled to optical resonators. These systems enable large optical Stark shifts and all optical switching with only a few photons.

CLEO: Science & Innovations

10:30–12:15
CThK • CLEO Symposium on Broadband Spectroscopy: New Techniques and Sources I: Dual-Comb Heterodyne Spectroscopy
Scott Sanders, Univ. of Wisconsin-Madison, USA, Presider

CThK1 • 10:30 Invited
Optically referenced double comb interferometry: applications and technological needs, *Jerome Genest[1], Jean-Daniel Deschênes[1], Carlos Andres Perilla[1], Simon Potvin[1], Sylvain Boudreau[1]; [1]Departement de genie electrique et de genie informatique, Universite Laval, Canada.* Chirping to enhance dual comb interferometry is discussed, along with multiplicative noise. The signal providing the optical path difference axis is not at the carrier frequency. Applications less affected by the spectral range are proposed.

CThK2 • 11:00
High Accuracy Molecular Spectroscopy with Combs Broadened From 1.35 to 1.7 μm, *Alexander M. Zolot[1], Ian Coddington[1], Fabrizio Giorgetta[1], Esther Baumann[1], William Swann[1], Jeffrey Nicholson[2], Nathan Newbury[1]; [1]NIST, USA; [2]OFS Laboratories, USA.* A coherent dual comb spectrometer spanning over 45 THz in the NIR was constructed from broadened erbium fiber lasers. Gas phase water, methane, and acetylene spectra were measured and characterized toward establishing absolute frequency references.

CThK3 • 11:15
1.5 Octave Highly Coherent Fiber Frequency Comb, *Axel Ruehl[1,2], Kevin C. Cossel[3], Michael J. Martin[3], Hugh McKay[2], Brian Thomas[2], Ling Dong[4,2], Martin E. Fermann[2], John M. Dudley[5], Ingmar Hartl[2], Jun Ye[3]; [1]Inst. for Lasers, Life and Biophotonics, Vrije Universiteit Amsterdam, Netherlands; [2]IMRA America Inc., USA; [3]JILA, National Inst. of Standards and Technology and Univ. of Colorado, USA; [4]College of Engineering and Science, Clemson Univ., USA; [5]Dept. of Optics, Univ. of Franche-Comte, France.* We present a highly coherent Yb-fiber laser based frequency comb spanning nearly 1.5 spectral octaves. The coherence properties are investigated by optical beat experiments and numerical simulations.

CLEO: Science & Innovations

10:30–12:15
CThL • Fiber Based Sensors
Zuyuan He, Univ. of Tokyo, Japan, Presider
Scott Bisson, Sandia Natl. Labs, USA, Presider

CThL1 • 10:30
Distributed Sensing inside Long-length FBG at Region beyond Laser Coherence Length based on Synthesis of Optical Coherence Function, *Koji Kajiwara[1], Zuyuan He[1], Kazuo Hotate[1]; [1]Electrical Engineering and Information Systems, The Univ. of Tokyo, Japan.* Measurement of Bragg-wavelength distribution inside a long-length FBG at region beyond laser coherence length is demonstrated based on synthesis of optical coherence function for a multi-point distributed sensor system with wide measurement range.

CThL2 • 10:45
Integrated Optical Refractometer Based On Multimode Interference, *Jaime Viegas[1,4], Mona Mayeh[2], Paulo V. Marques[3,4], Faramarz Farahi[2]; [1]Masdar Inst., United Arab Emirates; [2]Center for Optoelectronics and Optical Communications, Univ. of North Carolina at Charlotte, USA; [3]Physics, Faculty of Sciences, Univ. of Porto, Portugal; [4]UOSE, INESC Porto, Portugal.* An integrated optical refractometer based on multimode interference, with sensitivity enhancement due to sub-micrometer axial features, is demostrated with experimental sensitivity as high as 3200 nm/RIU and resolution on the order of 5 ppm.

CThL3 • 11:00
Chirped and tilted fiber Bragg grating edge filter for in-fiber sensor interrogation, *Tuan Guo[1,2], Hwa-Yaw Tam[2], Jacques Albert[3]; [1]Inst. of Photonics Technology, Jinan Univ., China; [2]Dept. of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong; [3]Dept. of Electronics, Carleton Univ., Canada.* Power-referenced edge filter based on a linearly chirped and weakly tilted fiber Bragg grating is proposed. It provides a smooth transfer function with 0.7 dB/nm of discrimination over C-band for the temperature-self-compensated FBG interrogation.

CThL4 • 11:15
Precise Signal Processing Schemes in Resonator Fiber Optic Gyro with Bipolar Digital Serrodyne Phase Modulation Technique, *Xijing Wang[1], Zuyuan He[1], Kazuo Hotate[1]; [1]Electrical Engineering and Information Systems, The Univ. of Tokyo, Japan.* Precise signal processing schemes for resonator fiber optic gyro with bipolar digital serrodyne phase modulation are proposed with suppressed noise induced by higher harmonics and stabilized control signal to adjust amplitude of phase modulation waveform.

10:30–12:00
CThM • Bandgap and Crystalline Fibers
Siddharth Ramachandran, Boston Univ., USA, Presider

CThM1 • 10:30
Sub-picosecond microjoule-class fiber lasers, *Caroline Lecaplain[1], Bülend Ortaç[2], Guillaume Machinet[3], Johan Boullet[3], Martin Baumgartl[4], Thomas Schreiber[5], Eric Cormier[3], Ammar Hideur[1]; [1]UMR CNRS 6614 CORIA, France; [2]UNAM-Inst. of Materials Science and Nanotechnology, Turkey; [3]CELIA, France; [4]Inst. of Applied Physics, Germany; [5]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We study the impact of the mode-locking mechanism on the performances of a microjoule-class all-normal dispersion fiber laser featuring large-mode-area photonic crystal fibers.

CThM2 • 10:45
Bench Top Milli-Joule Energy-level Nanosecond Pulse Delivery through Hollow-core Fiber, *Benoit Beaudou[1], Frédéric Gérôme[1], Gael Gaborel[2], Georges Humbert[1], Jean-Louis Auguste[1], Yu Cheng[3], Jean-Marc Blondy[1], Fetah Benabid[1,3]; [1]Xlim, France; [2]Meggitt Sensing Systems, France; [3]CPPM-Univ. of Bath, UK.* We report on the fabrication of a large pitch hollow-core fiber designed for maximizing energy transmission at 1064nm. Due to an air-mode/silica overlap reduced to 0.05%, a first demonstration of 4mJ nanosecond-pulses coupling is achieved.

CThM3 • 11:00
Practically Deployable and Effectively Single Mode All-Solid Photonic Bandgap Fiber with Large Effective Area, *Masahiro Kashiwagi[1], Saitoh Kunimasa[2], Takenaga Katsuhiro[1], Tanigawa Shoji[1], Matsuo Shoichiro[1], Fujimaki Munehisa[1]; [1]Fujikura Ltd., Japan; [2]Hokkaido Univ., Japan.* We have designed and fabricated a practically deployable large effective area all-solid photonic bandgap fiber. Effectively single mode operation and 440 μm^2 effective area were achieved at a 7.5 cm-bending radius.

CThM4 • 11:15
Quaternary One-Dimensional Photonic Crystal Cladding Hollow-Core Bragg Fiber, *Lichao Shi[1,2], Wei Zhang[1,2], Jie Jin[1,2], Yidong Huang[1,2], Jiangde Peng[1,2]; [1]Dept. of Electronic Engineering, Tsinghua Univ., China; [2]Tsinghua National Lab for Information Science and Technology, China.* We proposed and fabricated hollow-core Bragg fiber with quaternary one-dimensional photonic crystal cladding. The cladding increases the design flexibility. The transmission measurements revealed it guides light by the higher order photonic bandgaps.

10:30–12:15
CThN • THz Waveguides
Yujie Ding, Lehigh Univ., USA, Presider

CThN1 • 10:30
Ultra Low Bending Loss Spiral Photonic Crystal Fibers in Terahertz Regime, *Arti Agrawal[1], J. Kejalakshmy[1], M. Uthman[1], B. M. Rahman[1], K. T. Grattan[1]; [1]Electrical Engineering, City Univ. London, UK.* A spiral PCF design in Topas® with ultra low bending loss, very low confinement loss and superior dispersion properties in the Terahertz regime is presented. The design provides parameters for optimal performance over several characteristics.

CThN2 • 10:45
Analysis of resonant cavity geometries in a THz TE_1-mode parallel-plate waveguide, *Victoria Astley[1], Blake McCracken[1], Rajind Mendis[1], Daniel Mittleman[1]; [1]Dept. of Electrical and Computer Engineering, Rice Univ., USA.* We describe an experimental and computational study of the dependence of narrow resonances on geometry for rectangular resonant cavities in THz TE_1-mode parallel-plate waveguides. Increased Q-values can be obtained by modifying the cavity geometry.

CThN3 • 11:00
A new technique to measure loss, effective refractive index and electric field distribution of THz porous fibers, *Shaghik Atakaramians[1,2], Shahraam Afshar V.[2], Michael Nagel[3], Tanya M. Monro[2], Derek Abbott[1]; [1]School of Electrical & Electronic Engineering, The Univ. of Adelaide, Australia; [2]School of Chemistry & Physics, The Univeristy of Adleaide, Australia; [3]Institut für Halbleitertechnik, RWTH Aachen Univ., Germany.* We developed a new technique, employing a probe-tip, to measure both αeff and neff of porous fibers. Moreover, using this approach, we measure the evanescent electric field as a function of frequency.

CThN4 • 11:15
Suspended core polymer fibers with isolated mode for terahertz guiding, *Bora Ung[1], Mathieu Rozé[1], Anna Mazhorova[1], Markus Walther[2], Maksim Skorobogatiy[1]; [1]Engineering physics, Ecole Polytechnique de Montreal, Canada; [2]Materials Research Center, Univ. of Freiburg, Germany.* The fabrication and characterization of polymer suspended core fibers (porous and non-porous) for terahertz guiding is demonstrated for the first time. These novel fibers enable strong mode isolation from perturbations in the surrounding environment.

CLEO: QELS-Fundamental Science

10:30–12:15
QThH • Nonlinear and Ultrafast Nanophotonics
Mario Hentschel, Univ. of Stuttgart, Germany, Presider

QThH1 • 10:30
Metamolecular Nonlinear Optics, *Hannu Husu[1], Roope Siikanen[1], Goery Genty[1], Henna Pietarinen[1], Martti Kauranen[1], Joonas Lehtolahti[2], Janne Laukkanen[2], Markku Kuittinen[2]; [1]Dept. of Physics, Tampere Univ. of Technology, Finland; [2]Dept. of Physics and Mathematics, Univ. of Eastern Finland, Finland.* We vary relative arrangement of anisotropic metal nanoparticles (metamolecules) in arrays. Their second-harmonic response is not a simple orientational average of the molecular responses. Instead, collective resonances of the structures dominate.

QThH2 • 10:45
Multi-photon Autocorrelation in Gold Nanostructures, *Daniele Brida[1], Paolo Biagioni[1], Jer-Shing Huang[2], Johannes Kern[3], Matteo Savoini[1], Lamberto Duò[1], Bert Hecht[3], Marco Finazzi[1], Giulio Cerullo[1]; [1]Politecnico di Milano, Italy; [2]National Tsing-Hua Univ., Taiwan; [3]Universität Würzburg, Germany.* We performed interferometric autocorrelation of ultrashort laser pulses using the multi-photon photoluminescence of gold nanostructures. We observe an incoherent contribution with a decay constant related to electron cooling in the conduction band.

QThH3 • 11:00
Ultrafast observation of weak coupling effects in ZnO-Ag heterostructures, *Benjamin Lawrie[1], Richard Mu[2], Richard F. Haglund[3]; [1]Interdisciplinary Materials Science, Vanderbilt Univ., USA; [2]Dept. of Physics, Fisk Univ., USA; [3]Dept. of Physics and Astronomy, Vanderbilt Univ., USA.* Pump-probe-spectroscopy on ZnO/MgO heterostructures demonstrates a 600fs decay to impurity bound excitons located near the ZnO/MgO interface. Surface-plasmon-polaritons supported on a 30nm Ag film quench this process through weak coupling effects.

QThH4 • 11:15
Silicon Based Ultrafast Active Plasmonics near 1.5 µm, *Jan Niklas Caspers[1], Nir Rotenberg[1], Henry M. van Driel[1]; [1]Dep. of Physics and Inst. for Optical Science (IOS), Univ. of Toronto, Canada.* Light plasmon coupling resonances near 1.5 µm are optically shifted by nearly 50 nm on a gold-coated silicon grating for 800 fs, 775 nm excitation; recovery occurs in ~70 ps.

JOINT

10:30–12:15
JThA • Microscopic Imaging and Endoscopy
Yu Chen, Univ. of Maryland, USA, Presider

JThA1 • 10:30 Invited
Fiber-optic Two-photon Fluorescence and Second Harmonic Generation Endomicroscopy, *Yuyiing Zhang[1], Kartikeya Murari[1], Jiefeng Xi[1], Yongping Chen[1], Meredith Arkin[2], Samata Kakkad[3], Mala Mahendroo[2], Kate Luby-Phelps[4], Shenping Li[5], Zaver Bhujwalla[3], Kristine Glunde[3], Ming-Jun Li[5], Xingde Li[1]; [1]Biomedical Engineering, Johns Hopkins Univ., USA; [2]Obstetric and Gynecology, UT Southwestern Medical Center, USA; [3]Radiology, Johns Hopkins Univ., USA; [4]Cell Biology, UT Southwestern Medical Center, USA; [5]Science & Technology Division, Corning Incorporated, USA.* We present updates on recent developments of a fully integrated, ultracompact fiber-optic scanning endomicroscope for nonlinear optical imaging. Approaches to significantly improve signal collection efficiency and resolution will be discussed.

JThA2 • 11:00
Full-Range, Complex-Conjugate-Free, Endoscopic Spectral-Domain Optical Coherence Tomography, *Kang Zhang[1], Yong Huang[1], Jin U. Kang[1]; [1]Electrical and Computer Engineering, Johns Hopkins Univ., USA.* We implemented full-range, complex-conjugate-free, endoscopic SD-OCT with a forward-viewing miniature resonant fiber-scanning probe and phase modulation in the reference-arm. This method can be applied to various endoscopic SD-OCT systems.

JThA3 • 11:15
Optical Coherence Tomography Forward-Imaging Needle for Real-time Deep Brain Surgery Guidance, *Chia-Pin Liang[1], Jerry Wierwille[1], Thais Moreira[2], Musab S. Jafri[2], Cha-Min Tang[2], Yu Chen[1]; [1]Bioengineering, Univ. of Maryland, College Park, USA; [2]Neurology, Univ. of Maryland School of Medicine, USA.* We have developed a real-time (16 frames/second), narrowest to-date (700-um-diam) optical coherence tomography (OCT) forward-imaging needle and demonstrated its feasibility for guiding deep brain surgery based on both structural and Doppler imaging.

CLEO: Science & Innovations

10:30–12:00
CThO • OFDM
René-Jean Essiambre, Bell Labs, Alcatel-Lucent, USA, Presider

CThO1 • 10:30 Invited
All-optical Real-time OFDM Transmitter and Receiver, *Wolfgang Freude[1], David Hillerkuss[1], Thomas Schellinger[1], Rene Schmogrow[1], Marcus Winter[1], Thomas Vallaitis[1], Rene Bonk[1], Andrej Marculescu[1], Jingshi Li[1], Michael Dreschmann[2], Joachim Meyer[2], Shalva Ben Ezra[3], Mordechai (Motti) Caspi[3], Bernd Nebendahl[4], Francesca Parmigiani[5], Periklis Petropoulos[5], Bojan Resan[6], Andreas E. H. Oehler[6], Kurt Weingarten[6], Tobias Ellermeyer[7], Joachim Lutz[7], Michael Moeller[7], Michael Huebner[2], Juergen Becker[2], Christian Koos[1], Juerg Leuthold[1]; [1]Inst. of Photonics and Quantum Electronics (IPQ), Karlsruhe Inst. of Technology (KIT), Germany; [2]Inst. of Information Processing Technology (ITIV), Karlsruhe Inst. of Technology (KIT), Germany; [3]Finisar Corporation, Israel; [4]Agilent Technologies, Germany; [5]Optoelectronics Research Centre, UK; [6]Time-Bandwidth Products, Switzerland; [7]Micram Microelectronic GmbH, Germany.* OFDM has emerged as a promising modulation technique in long-haul and access optical networks. The computational complexity of the format can be met with powerful digital signal processors, and especially by exploiting all-optical signal processing.

CThO2 • 11:00
Characterization of Fast and Power Efficient Optical OFDM Transmission System Based on Hartley Transform, *Michela Svaluto Moreolo[1], Josep Maria Fabrega[1], Gabriel Junyent[1]; [1]Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain.* The analysis in unamplified and ASE-dominated optical systems shows that similar performance as DMT can be achieved with FHT-based O-OFDM, providing an efficient scheme in terms of power and complexity for cost-sensitive applications.

CThO3 • 11:15
Coarse Optical Orthogonal Frequency Division Multiplexing for Optical Datacommunication Applications, *Sim Heung Lee[1], Liang Geng[1], Jonathan D. Ingham[1], Richard V. Penty[1], Ian H. White[1], David Cunningham[2]; [1]Univ. of Cambridge, UK; [2]Avago Technologies, UK.* We propose a low-cost solution using orthogonal transmission of NRZ and CAP format data to realize a coarse OFDM transmission system. Using low bandwidth electronics and optoelectronic components, the system is demonstrated at 37.5Gb/s.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

10:30–12:15
QThI • Optical Filamentation and Related Nonlinear Phenomena
Eric Van Stryland, CREOL, The College of Optics and Photonics, USA, Presider

QThI1 • 10:30
Energy exchange between two filaments in air via a traveling plasma grating, *Magali Durand[1,2], Yi Liu[1], Benjamin Forestier[1], Aurélien Houard[1], André Mysyrowicz[1]; [1]Laboratoire d'Optique Appliquée, ENSTA ParisTech, Ecole Polytechnique, CNRS, France; [2]Département d'Optique Théorique et Appliquée, ONERA, France.* We observe efficient energy exchange between filaments in air mediated by a travelling plasma grating formed at the intersection of the two filaments. The velocity of this grating is studied by means of Doppler effect.

QThI2 • 10:45
Spontaneous currents inside air filaments, *Bing Zhou[1], Aurélien Houard[1], Yi Liu[1], Bernard Prade[1], André Mysyrowicz[1], Arnaud Couairon[2], Patrick Mora[2], Christopher Smeenk[3], Ladan Arissian[3], Paul Corkum[3]; [1]LOA, ENSTA ParisTech, Ecole Polytechnique, CNRS, France; [2]CPHT, Ecole Polytechnique, CNRS, France; [3]National Research Council, Canada.* Currents circulating in the plasma column of filaments in air are detected with a fast current monitor. The currents can be amplified with circularly polarized light.

QThI3 • 11:00
Measurement and control of electric currents in Ar and N_2 filaments, *Bing Zhou[1], Aurélien Houard[1], Yi Liu[1], Bernard Prade[1], André Mysyrowicz[2], Arnaud Couairon[2], Patrick Mora[2], Christopher Smeenk[3], Ladan Arissian[3], Paul Corkum[3]; [1]LOA, ENSTA ParisTech, Ecole Polytechnique, CNRS, France; [2]CPHT, Ecole Polytechnique, CNRS, France; [3]National Research Council, Canada.* Spontaneous currents inside the plasma column of filaments of N_2 and Argon circulate in opposite directions. A competition between the laser Lorentz force and a Coulomb wake force explains the difference.

QThI4 • 11:15
Multi-dimensional plasma grating from filament interaction in air, *Jia Liu[1], Haifeng Pan[1], Jian Wu[1], Heping Zeng[1]; [1]State Key Lab of Precision Spectroscopy, East China Normal Univ., China.* We demonstrated the formation of 2D plasma grating by noncollinear interaction of femtosecond filaments in air. The 2D photonic plasma supported 2D diffraction of the generated third-harmonic pulses.

10:30–12:15
QThJ • Quantum Storage and Frequency Entanglement
Ulrik Lund Andersen, DTU, Denmark, Presider

QThJ1 • 10:30
Single-photon-level memory at room temperature, *Klaus F. Reim[1], Patrick Michelberger[1], Ka C. Lee[1], Joshua Nunn[1], Nathan K. Langford[1], Ian A. Walmsley[1]; [1]Physics, Univ. of Oxford, UK.* We present an efficient broadband optical single-photon-level room-temperature memory, capable of operating with a low unconditional noise floor in the quantum regime, with memory efficiencies exceeding 30nd storage times of up to 4 μs.

QThJ2 • 10:45
Free-space Photon Storage with Variable Time Delays, *Bradley G. Christensen[1], Kevin McCusker[1], Michael Goggin[2], Katie Crimmins[1], Paul Kwiat[1]; [1]Physics, Univ. of Illinois, USA; [2]Physics, Truman State Univ., USA.* We discuss a high-efficiency "digital" photon storage system using multiple optical cavities to create variable storage times.

QThJ3 • 11:00
Extending Quantum Optical Benchmarks with Entanglement Measures, *Nathan Killoran[1], Norbert Lütkenhaus[1]; [1]Inst. for Quantum Computing & Dept. of Physics and Astronomy, Univ. of Waterloo, Canada.* Benchmarks based on entanglement verification can show when optical devices are in the quantum domain. Using no additional resources, we extend existing benchmarks to rigorously quantify the entanglement, covering nearly all of the quantum domain.

QThJ4 • 11:15
Cold Atoms Coupled to a Superconducting Flux Qubit, *Jeffrey A. Grover[1], Jonathan Hoffman[1], Zaeill Kim[1], Austin Wood[1], James R. Anderson[1], Alex J. Dragt[1], Mohammad Hafezi[1], Christopher J. Lobb[1], Luis A. Orozco[1], Steven L. Rolston[1], Jacob M. Taylor[1], Constantine P. Vlahacos[1], Fred C. Wellstood[1]; [1]Joint Quantum Inst., National Inst. of Standards and Technology and Dept. of Physics, Univ. of Maryland, College Park, USA.* We present a scheme and our advances to magnetically couple ^{87}Rb atoms to a superconducting flux qubit by trapping the atoms in the evanescent wave outside an tapered optical fiber.

10:30–12:15
CThP • Silicon Optical Links
John Bowers, Univ. of California at Santa Barbara, USA, Presider

CThP1 • 10:30
Polarization insensitive Grating Coupler for Lightwave Coupling between Silicon Nanophotonic Waveguide and Surface Mounted Photodetector, *Ryohei Takei[1], Kotaro Uchiho[1], Tetsuya Mizumoto[1]; [1]Electrical and Electronic Engineering, Tokyo Inst. of Technology, Japan.* The lightwave connection of silicon chips and external elements is a serious problem. The grating coupler is effective for the connection of the surface mounted photodetector. We demonstrate the polarization insensitive operation.

CThP2 • 10:45
Dynamic Sub-20 ns Reconfiguration of a Silicon CMOS Photonic Filter and Filter Shape Measurement, *Binbin Guan[1], Nicolas K. Fontaine[1], Ryan P. Scott[1], David J. Geisler[1], Stevan Djordjevic[1], Salah Ibrahim[1], Stanley Cheung[1], Tiehui Su[1], Andrew T. Pomerene[2], Liberty Gunter[2], Steve Danziger[2], Zhi Ding[1], S. J. Ben Yoo[1]; [1]Univ. of California at Davis, USA; [2]BAE Systems North America, USA.* Dynamic filter shapes of a silicon photonic lattice filter switching between a notch and bandpass filter are measured at a 16.67 ns interval using a frequency-to-time mapping method and a coherent measurement technique.

CThP3 • 11:00
CMOS-Compatible Temperature Insensitive Silicon Microring Modulator, *Biswajeet Guha[1], Kyle Preston[1], Michal Lipson[1,2]; [1]Electrical & Computer Engineering, Cornell Univ., USA; [2]Kavli Inst. at Cornell for Nanoscience, USA.* We demonstrate a passively temperature stabilized silicon electro-optic modulator, consisting of a ring resonator coupled to a Mach-Zehnder interferometer with tailored mode confinement. We show 2 GHz modulation over 40°C temperature range.

CThP4 • 11:15
Performance Guidelines for WDM Interconnects Based on Silicon Microring Resonators, *Kyle Preston[1], Nicolás Sherwood-Droz[1], Jacob S. Levy[1], Michal Lipson[1]; [1]Electrical and Computer Engineering, Cornell Univ., USA.* We derive fundamental performance tradeoffs that determine bandwidth and optical power budget in large-scale WDM links or networks utilizing silicon microresonators. Bandwidth per waveguide scales to >1THz, but nonlinearities limit optical power to milliwatt levels.

CLEO: QELS-Fundamental Science

QThF • Disordered Material—Continued

QThF5 • 11:30
Quantum Interference of Multiple Beams Induced by Multiple Scattering, *Johan R. Ott[1], N. Asger Mortensen[1], Peter Lodahl[1]; [1]Dept. of Photonics Engineering, Technical Univ. of Denmark (DTU), Denmark.* We report on quantum interference induced by the transmission of quantized light through a multiple-scattering medium. We show that entangled states can be created by multiple-scattering and that quantum interference survives disorder averaging.

QThF6 • 11:45
Light Localization in Disordered Metamaterials, *Salvatore Savo[1], Nikitas Papasimakis[1], Nikolay I. Zheludev[1]; [1]Optoelectronics research center, Univ. of Southampton, UK.* For the first time we demonstrate localization of electromagnetic radiation in disordered planar metamaterials. The statistics of near-field intensity indicate that the localization is linked to subradiant modes in the metamolecules.

QThF7 • 12:00
Coupled defect-waveguides in amorphous photonic lattices: Enhanced coupling through randomness, *Alexander Szameit[1], Mikael C. Rechtsman[1], Matthias Heinrich[2], Felix Dreisow[2], Robert Keil[2], Stefan Nolte[2], Moti Segev[1]; [1]Physics, Technion, Israel; [2]Physics, Friedrich-Schiller-Universität, Germany.* We present, experimentally and theoretically, coupled defect-waveguides in an amorphous photonic lattice, exhibiting enhanced coupling by virtue of disorder.

CLEO: Science & Innovations

CThJ • Optomechanics I—Continued

CThJ5 • 11:30
High Q optomechanical resonators in silicon nitride nanophotonic circuits, *King Yan Fong[1], Wolfram H. Pernice[1], Mo Li[2], Hong Tang[1]; [1]Yale Univ., USA; [2]Univ. of Minnesota, USA.* We demonstrate nanophotonic circuits for integration of high Q micromechanical resonators and nanooptical components. Mechanical resonance of nanostring is actuated and readout by optomechanical interaction. Quality factor up to 696,000 is obtained.

CThJ6 • 11:45
Silicon Opto-Acoustic Oscillator, *Suresh Sridaran[1], Sunil A. Bhave[1]; [1]Electrical and Computer engineering, Cornell Univ., USA.* Improved modulation depth of MEMS based optical modulators is obtained using implantation to reduce resistance. The increased output power enables closing of optical-electrical loop around the modulator to make an Opto-Acoustic Oscillator at 237MHz.

CThJ7 • 12:00
Electromechanically Tunable Photonic Crystal Cavities, *Leonardo Midolo[1], Rene J. van Veldhoven[1], Richard Noetzel[1], Mehmet A. Dundar[1], Andrea Fiore[1]; [1]Applied Physics, COBRA Research Inst., Eindhoven Univ. of Technology, Netherlands.* We report a novel approach to tuning photonic crystal cavities based on the electrostatic actuation of coupled InGaAsP membranes and we report up to 7 nm mode shift with 8.6 V bias.

CLEO: QELS-Fundamental Science

QThG • Symposium on The Zeno Effect in Optoelectronics and Quantum Optics II—Continued

QThG4 • 11:30
A Compact Orbital Angular Momentum Spectrometer Using Quantum Zeno Interrogation, *Paul Bierdz[1], Hui Deng[1]; [1]Physics, Univ. of Michigan, USA.* We present a scheme to measure the spectrum of orbital angular momenta of light using a precisely timed optical loop and quantum non-demolition measurements. We also discuss the influence of imperfect optical components.

QThG5 • 11:45
All-optical switching via inverse Raman scattering in an optical fiber, *Khanh Kieu[1], Lukas Schneebeli[1], Joel Hales[2], Joseph W. Perry[2], Robert Norwood[1], Nasser Peyghambarian[1]; [1]Univ. of Arizona, USA; [2]Georgia Tech, USA.* We report the observation of inverse Raman scattering (IRS) in optical fiber. The achieved level of attenuation via IRS in an optical fiber is > 20dB at a time scale < 5ps.

CLEO: Science & Innovations

CThK • CLEO Symposium on Broadband Spectroscopy: New Techniques and Sources I: Dual-Comb Heterodyne Spectroscopy—Continued

CThK4 • 11:30 Invited
Molecular Spectroscopy with Laser Frequency Combs, *Theodor W. Hänsch[1,2], Nathalie Picqué[1,2]; [1]Max Planck Institut für Quantenoptik, Germany; [2]Ludwig-Maximilians-Universität München, Germany.* The millions of precisely controlled laser comb lines produced with a train of ultrashort laser pulses can harnessed for highly-multiplexed molecular spectroscopy. Multi-heterodyne spectroscopy with frequency combs is emerging as a powerful new tool.

CThK5 • 12:00
Suitability of supercontinuum light near 2 μm for coherent dual comb spectroscopy, *Kevin Knabe[1], Paul A. Williams[1], Nathan Newbury[1]; [1]PML, NIST, USA.* We evaluate the signal-to-noise ratio penalty for dual comb spectroscopy caused by the excess optical phase noise and relative intensity noise on the long-wavelength supercontinuum of a spectrally broadened Er-fiber laser frequency comb.

10:30–15:00 Technology Transfer Showcase (Panel Discussion and Tabletop Display), *Exhibit Hall F, 100 Level*

12:15–13:00 Lunch Break *(concessions available in Exhibit Halls E and F, 100 Level)*

CLEO: Science & Innovations

CThL • Fiber Based Sensors—Continued

CThL5 • 11:30
Enlargement of Measurement Range by Double Frequency Modulations in One-Laser Brillouin Correlation-Domain Distributed Discrimination System, *Weiwen Zou[1,2], Zuyuan He[1], Kazuo Hotate[1]; [1]Dept. of Electrical Engineering and Information Systems, Univ. of Tokyo, Japan; [2]Dept. of Electronic Engineering, Shanghai Jiao Tong Univ., China.* A new scheme based on double frequency modulations is proposed to enlarge the measurement range in Brillouin correlation-domain distributed discrimination system with one laser source.

CThL6 • 11:45
VCSEL-based tilted fiber grating vibration sensing system, *Tuan Guo[1,2], Yuheng Huang[3], Bai-Ou Guan[1], Chao Lu[3], Hwa-Yaw Tam[2], Jacques Albert[4]; [1]Inst. of Photonics Technology, Jinan Univ., China; [2]Dept. of Electrical Engineering, The Hong Kong Polytechnic Univ., Hong Kong; [3]Dept. of Electronic and Information Engineering, The Hong Kong Polytechnic Univ., Hong Kong; [4]Dept. of Electronics, Carleton Univ., Canada.* Fiber-optic vibration sensing system using tilted fiber grating and vertical-cavity surface-emitting laser (VCSEL) has been demonstrated. Dynamic vibration measurement up to 200 Hz with improved signal-to-noise ratio better than 40 dB was achieved.

CThL7 • 12:00
Detection of single nanoparticles using a nano fiber-taper, *Jiangang Zhu[1], Sahin K. Ozdemir[1], Lina He[1], Da-Ren Chen[2], Lan Yang[1]; [1]Electrical & Systems Engineering, Washington Univ. in St. Louis, USA; [2]Energy, Environmental & Chemical Engineering, Washington Univ. in St. Louis, USA.* We present a sensitive single nanoparticle detection scheme using a nano tapered fiber. Experiments of detecting R = 120 nm and 175 nm polystyrene (PS) nanoparticles at 1550 nm wavelength band are demonstrated.

CThM • Bandgap and Crystalline Fibers—Continued

CThM5 • 11:30 Invited
Semiconductor Core Optical Fiber, *John Ballato[1], T. Hawkins[1], P. Foy[1], C. McMillen[2], S. Morris[1], R. Stolen[1], J. Fan[3], L. Zhu[3], R. Rice[4]; [1]School of Materials Science and Engineering, USA; [2]Dept. of Chemistry, USA; [3]Dept. of Electrical and Computer Engineering, USA; [4]DreamCatchers Consulting, USA.* Progress in the fabrication and performance of glass-clad crystalline semiconductor core optical fibers is reviewed. This new class of optical fibers may significantly advance applications in nonlinear optics and infrared power delivery.

CThN • THz Waveguides—Continued

CThN5 • 11:30
Low-loss hollow metallic waveguides efficiently coupled to Terahertz micro-ring quantum cascade lasers, *Miriam Vitiello[1,2], Ji-Hua Xu[2], Mirgender Kumar[2], Fabio Beltram[2], Alessandro Tredicucci[2], Oleg Mitrofanov[3], Harvey E. Beere[4], David A. Ritchie[4]; [1]CNR-IFAC, Italy; [2]NEST, CNR-NANO and Scuola Normale Superiore, Italy; [3]Dept. of Electronic and Electrical Engineering, Univ. College London, UK; [4]Cavendish Lab, Univ. of Cambridge, UK.* We demonstrate that the azimuthally polarized beam of a micro-ring THz quantum-cascade laser can be coupled to hollow metallic waveguides with efficiencies ≥96% and perfectly matched with the TE_{01} waveguide mode, giving attenuation losses <3dB/m.

CThN6 • 11:45
The Transition from TEM-like Mode to Plasmonic Mode in Finite-width THz Parallel-plate Waveguide, *Jingbo Liu[1], Rajind Mendis[1], Daniel Mittleman[1]; [1]ECE Dept., RICE UNIV., USA.* We report the near-field measurement of the electric field distribution inside the metal PPWG. We observe the transition from TEM-like mode to plasmonic mode. This mode transition depends on the geometry of the waveguide.

CThN7 • 12:00
Sub-Wavelength Plasmonic Mode Confinement in Semiconductor-Gap-Dielectric Waveguide in THz range, *Hovhannes Haroyan[1], Yuri Avetisyan[1], Masayoshi Tonouchi[2]; [1]Microwave Eng., Yerevan State Univ., Armenia; [2]Inst. of Laser Engineering Osaka Univ., Japan.* We have investigated the dispersion relation of a novel semiconductor-gap-dielectric waveguide in terahertz range. It is shown that InSb-SiO_2-Si structure supports strongly confined guided mode with area of $6.6 \times 10^{-5}\ \lambda^2$ at 1 THz.

10:30–15:00 Technology Transfer Showcase (Panel Discussion and Tabletop Display), *Exhibit Hall F, 100 Level*

12:15–13:00 Lunch Break *(concessions available in Exhibit Halls E and F, 100 Level)*

CLEO: QELS-Fundamental Science

QThH • Nonlinear and Ultrafast Nanophotonics—Continued

QThH5 • 11:30
Nonlinear Optics of Magnetic Plasmonic Nanostructures, *Irina A. Kolmychek[1], Tatyana V. Murzina[1], Oleg A. Aktsipetrov[1]; [1]Moscow State Lomonosov Univ., Russian Federation.* Magnetization-induced second harmonic generation in core(shell) Fe_2O_3(Au) nanoparticles and Au/Co/Au nanosandwiches was studied in the transversal Kerr effect geometry. Plasmon-assisted changes in the nonlinear magneto-optical response were revealed.

QThH6 • 11:45
Ultrasensitive On-Chip Photonic Crystal Nanobeam Sensor using Optical Bistability, *Qimin Quan[1], Frank Vollmer[2], Ian B. Burgess[1], Parag B. Deotare[1], Ian Frank[1], Sindy Tang[1], Rob Illic[3], Marko Loncar[1]; [1]School of Engineering and Applied Sciences, Harvard Univ., USA; [2]Wyss Inst., Harvard Univ., USA; [3]Cornell Nanoscale Science and Technology Facility, Cornell Univ., USA.* An ultrasensitive nonlinear cavity sensing method is proposed and demonstrated, in which the detection limit is not bounded by the quality factor of the cavity. 10mg/dL glucose concentration and 100aM BSA molecules are detected.

QThH7 • 12:00
Picosecond Few-Fermion Dynamics of a Single Self-Assembled InGaAs Quantum Dot, *Markus Betz[1], Markus Zecherle[2], Claudia Ruppert[2], Emily Clark[3], Jonathan Finley[3]; [1]Experimentelle Physik 2, TU Dortmund, Germany; [2]Physik-Dept. E11, TU München, Germany; [3]Walter Schottky-Institut und Physik-Dept. E24, TU München, Germany.* Population dynamics, excited biexciton states, excitonic and conditional biexcitonic Rabi oscillations in a single quantum dot embedded in a photodiode are investigated combining ultrafast pump-probe techniques with sensitive photocurrent readout.

JOINT

JThA • Microscopic Imaging and Endoscopy—Continued

JThA4 • 11:30
Optical Coherence Tomography Guided Breast Biopsy, *Nicusor Iftimia[1]; [1]Physical Sciences Inc, USA.* We present an optical coherence tomography (OCT) based approach for breast biopsy guidance. The detailed description of the instrumentation and the preliminary results on an animal model of breast cancer will be discussed.

JThA5 • 11:45
Simultaneous Morphological and Biochemical Imaging of Oral Epithelial Cancer in a Hamster Cheek Pouch Model, *Brian E. Applegate[1], Jesung Park[1], Sebina Shrestha[1], Paritosh Pande[1], Irma B. Gimenez-Conti[2], Jimi L. Brandon[2]; [1]Biomedical Engineering, Texas A&M Univ., USA; [2]Dept. of Carcinogenesis, Univ. of Texas MD Anderson Cancer Center, USA.* We present the results of an animal study aimed at determining the value of collecting both morphological and biochemical images for oral cancer diagnosis using a multimodal optical coherence tomography and fluorescence lifetime imaging system.

JThA6 • 12:00
Monitoring of germination dynamics of multiple individual bacterial spores by multiple-trap Raman tweezers and differential interference contrast microscopy, *Pengfei Zhang[1], Lingbo Kong[1], Peter Setlow[2], Yong-qing Li[1]; [1]East Carolina Univ., USA; [2]Univ. of Connecticut Health Center, USA.* Multiple-trap Raman tweezers and differential interference contrast microscopy were used for simultaneously monitoring the germination dynamics of multiple individual bacterial spores.

CLEO: Science & Innovations

CThO • OFDM—Continued

CThO4 • 11:30
Phase-Managed Alias Sampling in 1-Tb/s Coherent Optical OFDM, *Lin Cheng[1], He Wen[1], Xiaoping Zheng[1]; [1]Tsinghua Univ., China.* The sampling rate is reduced to half of the Nyquist frequency to release the ADC requirement in CO-OFDM system. An experiment of 1-Tb/s multi-band CO-OFDM with hybrid subcarrier modulations and phase-managed alias sampling is demonstrated.

CThO5 • 11:45
Experimental Demonstration of a Bandwidth Scalable LAN Emulation over EPON Employing OFDMA, *Lei Deng[1,2], Ying Zhao[1,3], Xianbin Yu[1], Valeria Arlunno[1], Robert Borkowski[1], Deming Liu[2], Idelfonso Tafur Monroy[1]; [1]DTU Fotonik, Technical Univ. of Denmark, Denmark; [2]School of Optoelectronics Science and Engineering, HuaZhong Univ. of Science and Technology, China; [3]Dept. of Electronic Engineering, Tsinghua Univ., China.* We propose a novel EPON system supporting bandwidth scalable local area network emulation by using orthogonal frequency division multiplexing access technology. Added to the EPON traffic, 250Mbps and 500Mbps OFDM LAN traffics are experimentally emulated.

10:30–15:00 Technology Transfer Showcase (Panel Discussion and Tabletop Display), *Exhibit Hall F, 100 Level*

12:15–13:00 Lunch Break *(concessions available in Exhibit Halls E and F, 100 Level)*

CLEO: QELS-Fundamental Science

QThI • Optical Filamentation and Related Nonlinear Phenomena—Continued

QThI5 • 11:30
Direct comparison of high-order harmonics generated in gas and in carbon plasma, *Yoann Pertot[1], Luc Elouga Bom[1], Shouyuan Chen[2], Sabih D. Khan[2], Zenghu Chang[2,3], Tsuneyuki Ozaki[1]; [1]Energie, matériaux et télécommunications, INRS-EMT, Canada; [2]Dept. of Physics, Kansas State Univ., USA; [3]Attosecond Science and Technology, Univ. of Central Florida, USA.* We perform the first direct comparison between high-order harmonics generated from carbon plasma and from argon gas cell, and find that the former is ten times more intense than the latter.

QThI6 • 11:45
Sub-1mJ Over-Two-Octave White-Light Continuum Generated by Induced Phase Modulation in Argon-Filled Hollow Fiber, *Shaobo Fang[1], Keisaku Yamane[1], Jiangfeng Zhu[1], Chun Zhou[2], Zhigang Zhang[2], Mikio Yamashita[1]; [1]Dept. of Applied Physics, Hokkaido Univ., and Core Research Evolutional Science and Technology, Japan Science and Technology Agency, Japan; [2]Inst. of Quantum Electronics, School of Electronics Engineering and Computer Science, State Key Lab of Advanced Optical Communication System and Networks, Peking Univ., China.* We generated 0.9-mJ pulses spanning from 270 to 1200 nm by utilizing the induced phase modulation in pressure gradient hollow fiber. This enables 1.5-fs, 0.65-cycles, 0.6-TW, 1-kHz transform-limited pulses for attosecond science and technology.

QThI7 • 12:00
Distinguishing instantaneous from rotational Kerr response in air using supercontinuum spectral interferometry, *Jared Wahlstrand[1], Yu-Hsiang Cheng[2], Howard Milchberg[1,2]; [1]Physics, Univ. of Maryland, USA; [2]Electrical and Computer Engineering, Univ. of Maryland, USA.* We measure the polarization dependence of the Kerr effect in air using single-shot supercontinuum spectral interferometry, enabling separation of the instantaneous and rotational components of the nonlinearity.

QThJ • Quantum Storage and Frequency Entanglement—Continued

QThJ5 • 11:30
Demonstration of a Scalable Multi-photon Entanglement Source, *Eli Megidish[1], Tomer Shacham[1], Assaf Halevy[1], Liat Dovrat[1], Hagai S. Eisenberg[1]; [1]Racah Inst. of Physics, Hebrew Univ. of Jerusalem, Israel.* We experimentally demonstrate a novel multiphoton entangling system that in principle can entangle any number of photons. Spatial degrees of freedom are replaced by temporal degrees of freedom. Four and six photon states are presented.

QThJ6 • 11:45
Scaling Multipartite Entanglement in the Optical Frequency Comb, *Matthew Pysher[1], Yoshichika Miwa[2], Reihaneh Shahrokhshahi[1], Russell Bloomer[1], Olivier Pfister[1]; [1]Dept. of Physics, Univ. of Virginia, USA; [2]Dept. of Applied Physics, Univ. of Tokyo, Japan.* We report the simultaneous experimental generation of multiple quadripartite continuous-variable cluster states in the optical frequency comb of a single optical parametric oscillator operating below threshold.

QThJ7 • 12:00
Interference of Two Photons of Different Color with Applications to Quantum Computing, *Michael Raymer[1], Hayden J. McGuinness[1], Steven van Enk[1], Colin J. McKinstrie[2]; [1]Univ. of Oregon, USA; [2]Bell Laboratories, Alcatel-Lucent, USA.* Two photons having different colors can undergo the Hong-Ou-Mandel interference effect if the usual beam splitter is replaced by Bragg scattering via four-wave mixing in an optical fiber, which acts as a frequency shifter.

CLEO: Science & Innovations

CThP • Silicon Optical Links—Continued

CThP5 • 11:30 Invited
A 4x12.5 Gbps CWDM Si Photonics Link using Integrated Hybrid Silicon Lasers, *Brian R. Koch[1], Andrew Alduino[1], Ling Liao[1], Richard Jones[1], Michael Morse[1], Brian Kim[1], Wei-Zen Lo[1], Juthika Basak[1], Hai-Feng Liu[1], Haisheng Rong[1], Matthew Sysak[1], Christine Krause[1], Rushdy Saba[2], Dror Lazar[2], Lior Horwitz[2], Roi Bar[2], Stas Litski[2], Ansheng Liu[1], Kevin Sullivan[1], Olufemi Dosunmu[1], Neil Na[1], Tao Yin[1], Frederick Haubensack[1], I-wei Hsieh[1], John Heck[1], Robert Beatty[1], Jock Bovington[1], Mario J. Paniccia[1]; [1]Photonics Technology Lab, Intel, USA; [2]Intel, Israel.* We demonstrate a 4 wavelength by 12.5Gbps Silicon Photonics CWDM link integrating all optical components, electronics, and packaging technologies required to form the link.

CThP6 • 12:00
Ultra-Compact TOSA/ROSA with 40-Gbps Transmission Rate Using Silicon Optical Benches Technology, *Chin-Ta Chen[1], Hsiao-Chin Lan[2,3], Hsu-Liang Hsiao[1,2], Bo-Kuan Shen[1], Chia-Chi Chang[1,2], Guan-Fu Lu[1], Jen-Yu Chang[1], Sheng-Lung Li[1], An-Nong Wen[2], Yo-Shen Len[4], Mount-Learn Wu[1]; [1]Dept. of Optics and Photonics, National Central Univ., Taiwan; [2]Centera Photonics Inc., Taiwan; [3]Optical Sciences Center, National Central Univ., Taiwan; [4]Dept. of Electrical Engineering, National Central Univ., Taiwan.* Miniaturized TOSA/ROSA by using silicon optical bench (SiOB) technology is experimentally demonstrated with parallel transmission of 4-channel×10-Gbps. Whole module assembly is passive alignment achievable, and no coupling lens needed.

10:30–15:00 Technology Transfer Showcase (Panel Discussion and Tabletop Display), *Exhibit Hall F, 100 Level*

12:15–13:00 Lunch Break *(concessions available in Exhibit Halls E and F, 100 Level)*

13:00–14:30
JThB • Nonlinear and Quantum Science and Measurements Joint Poster Session

CLEO:QELS–Fundamental Science 1: Quantum Optics of Atoms, Molecules and Solids

• *Quantum Correlations and Atomic Coherence*

JThB1
Pairwise Concurrence Dynamics of a 4 Qubit Model Beyond Rotating Wave Approximation, *S. M. Hashemi Rafsanjani[1], S. Agarwal[1], Joseph H. Eberly[1]; [1]Univ. of Rochester, USA.* We examine the entanglement dynamics of two two-level systems (A & B) each interacting with separate harmonic oscillators (a & b) in a regime where rotating wave approximation is not valid.

JThB2
Atomic vapor quantum memory for a photonic polarization qubit, *Young-Wook Cho[1], Yoon-Ho Kim[1]; [1]Dept. of Physics, Pohang Univ. of Science and Technology (POSTECH), Republic of Korea.* We report an experimental realization of a warm atomic vapor quantum memory for the photonic polarization qubit. We have fully characterized the memory with quantum process tomography.

JThB3
Quantum Correlations using Strong Optical Pulses in Rare Earth Ion Doped Crystals, *Patrick Ledingham[1], Jevon Longdell[1]; [1]The Univ. of Otago, New Zealand.* We use photon echo based protocols with cryogenic rare earth ion dopants to create photon streams with time separated correlations. Theoretically, these streams are non-classically correlated. We present results toward realizing this correlation.

JThB4
Analysis of Two Level Atom in Bichromatic Field: Entropy Flow and Search for the Carnot Cycle, *Robinjeet Singh[1], Kebei Jiang[1], Petr M. Anisimov[1], Harold Metcalf[2], Jonathan P. Dowling[1]; [1]Physics and Astronomy, Louisiana State Univ., USA; [2]Physics and Astronomy, Stony Brook Univ., USA.* We study the two-level atom interaction with bichromatic field to understand the entropy flow during this interaction in the absence of spontaneous emission. This flow is characterized by the Carnot cycle that demonstrates efficient cooling.

JThB5
Decay Time in a Cavity in Slow or Fast Light Regime, *Fabien Bretenaker[1], Thomas Lauprетre[1], Cedric Proux[1], Sylvain Schwartz[3], Fabienne Goldfarb[1], Rupamanjari Ghosh[2]; [1]Laboratoire Aime Cotton, CNRS, France; [2]School of Physical Sciences, Jawaharlal Nehru Univ., India; [3]Thales Research and Technology France, France.* We investigate the decay time of a cavity containing strong dispersion achived through EIT in $^4He^*$ with linear polarizations. The photon lifetime is shown to be governed by the group velocity of light.

JThB6
Time-Dependent Inhibited Spontaneous Emission, *David Branning[1], Young Ho Shin[1], Sarthak Khanal[1], Alan Migdall[2,3]; [1]Physics, Trinity College, USA; [2]National Inst. of Standards and Technology, USA; [3]Joint Quantum Inst., Univ. of Maryland, USA.* The spontaneous emission rate of photon pairs in a parametric downconverter can be inhibited by a cavity mirror. Using a fast switch, we detect photons within the cavity during times when the emission was inhibited.

JThB7
Full Quantum Mechanically Treatment of Squeezed Vacuum State Generation through Self-Rotation, *Kebei Jiang[1], Robinjeet Singh[1], Petr M. Anisimov[1], Hwang Lee[1], Jonathan P. Dowling[1]; [1]Physics and Astronomy, Louisiana State Univ., USA.* We present a full quantum mechanical picture of squeezed vacuum state generation via self-rotation in an X system. As a result, extra noise that is overlooked in semi-classical picture is found and its effect on the degree of squeezing is discussed.

JThB8
Generation of a macroscopic singlet state in an atomic ensemble, *Naeimeh Behbood[1], Mario Napolitano[1], Brice Dubost[1], Robert J. Sewell[1], Marco Koschorreck[1], Morgan W. Mitchell[1]; [1]ICFO, Spain.* We report on an experiment underway for generating singlet states in a cold atomic ensemble. We have developed a new detection system with the capability of real time measurement and feedback control.

JThB9
Spectral Properties of Rare-Earth-Ion Doped Whispering Gallery Mode Resonators, *David McAuslan[1], Dmitry Korystov[1], Jevon Longdell[1]; [1]Jack Dodd Centre for Photonics and Ultra-Cold Atoms, Physics Dept., Univ. of Otago, New Zealand.* The properties of a Pr^{3+}:Y_2SiO_5 resonator are measured as an initial step towards performing strong coupling cavity QED experiments. Using photon echoes the resonator mode volume is measured as 6.99×10^{-12} m^3 and the ions coherence time as 68 µs.

JThB10
Scalable Multi-Photon Coincidence-Counting Electronics, *David Branning[1], Young Ho Shin[1], Sarthak Khanal[1], Brandon Clary[1], Mark Beck[2]; [1]Physics, Trinity College, USA; [2]Physics, Whitman College, USA.* We present a multi-channel coincidence-counting module for use in quantum optics experiments. The module counts up to 4-fold coincidences at up to 84 MHz. Combined multiple modules can count M-order coincidences among N inputs.

JThB11
Search For Patterns In Single-Photon Polarization Sequences, *David Branning[1], Adam Katcher[1], Wayne Strange[1], Mark P. Silverman[1]; [1]Physics, Trinity College, USA.* Sequences of polarization measurements on single photons were subjected to comprehensive runs analysis without numerical unbiasing. No significant discrepancies with the predicted numbers of runs were observed, even with multi-photon events retained.

• *Quantum Dots*

JThB12
Extracting the radiative, nonradiative and spin-flip rate of single self-assembled quantum dots in photonic crystals, *Qin Wang[1], Søren Stobbe[1], Peter Lodahl[1]; [1]DTU-Fotonik, Denmark.* We have developed a practical method to study the decay dynamics of neutral excitons in single self-assembled quantum dots and verified it experimentally.

JThB13
Resonance fluorescence from quantum dots: beyond the Mollow triplet, *Anders M. Lund[1], Per Kaer[1], Michael Lorke[1], Jesper Mørk[1]; [1]DTU Fotonik - Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We show that the resonance fluorescence spectrum of a quantum dot excited by a strong pulse contains multiple peaks. An analytical model shows how the peak positions depend on pulse width and amplitude.

JThB14
Quantum control of two-photon inter-excited states transitions, *Jongseok Lim[1], Han-gyeol Lee[1], Sangkyung Lee[1], Jaewook Ahn[1]; [1]Physics, KAIST, Republic of Korea.* We demonstrate quantum control of two-photon inter-excited states transitions in a V-type atomic system. By varying linear and quadratic chirps, we project the transitions to coherent transient phenomena in a two-level system.

JThB15
Tunneling Current In A Double Quantum Dot Excitonic System, *Amit Joshi[1]; [1]Physics, EIU, USA.* Two coupled quantum dots entangled through their interaction with a cavity mode, including Forster and exciton-phonon interactions, allow for observation of the Josephson effect in terms of photon assisted tunneling current similar to super current.

CLEO:QELS–Fundamental Science 2: Quantum Science, Engineering and Technology

JThB16
Photon-number-resolving detection at 1.04 µm by coincidence frequency upconversion, *Kun Huang[1], Xiaorong Gu[1], Min Ren[1], Yi Jian[1], Haifeng Pan[1], E. Wu[1], Heping Zeng[1]; [1]State Key Lab of Precision Spectroscopy, East China Normal Univ., China.* We demonstrated the photon-number-resolving detection at 1.04 µm by coincidence frequency upconverison. The detection efficiency of 6.8% was obtained. The Poissionian distribution of the up-converted photons was observed directly.

JThB17
Single-photon detection at 1.55 µm using a bipolar gating signal, *Abdessattar Bouzid[1,2], Jum-Bum Park[1], Se Min Kim[1,3], Sung Moon[1]; [1]Center for Nanosystem Technology, Korea Inst. of Science and Technology, Republic of Korea; [2]Univ. of Science and Technology, Republic of Korea; [3]Dept. of physics, Inha Univ., Republic of Korea.* The effect of bipolar gating signal on afterpulsing in an InGaAs/InP single-photon detector is characterized at 1.55 µm. The results demonstrate that the use of bipolar gating signal can efficiently reduce the afterpulse noise.

JThB18
Frequency Down-Conversion of Non-Classical Light from Visible Wavelength to Telecom Wavelength Using Difference-Frequency Generation, *Rikizo Ikuta[1], Tsuyoshi Kitano[1], Yoshiaki Kusaka[1], Takashi Yamamoto[1], Masato Koashi[1], Nobuyuki Imoto[1]; [1]Graduate School of Engineering Science, Osaka Univ., Japan.* We experimentally demonstrate frequency down-conversion of non-classical light from 780 nm to 1522 nm by difference-frequency generation. The observed second-order correlation of the converted light is 0.54.

JThB19
Bayesian Analysis of Parity Based Detection Scheme, *Keith R. Motes[1], Petr M. Anisimov[1], Jonathan P. Dowling[1]; [1]Physics, LSU, USA.* Using Bayesian analysis we characterized performance of phase estimation in the Mach-Zehnder interferometer with two-mode squeezed vacuum input. Phase uncertainty, averaged over many trials, is examined and the dependence on photon number is found.

JThB20
Quantum Theory of Optical Coherence in the Space-frequency Domain, *Mayukh Lahiri[1], Emil Wolf[1,2]; [1]Dept. of Physics and Astronomy, Univ. of Rochester, USA; [2]Inst. of Optics, Univ. of Rochester, USA.* The quantum treatment of optical coherence theory is generally carried out in the space-time domain. We present a quantum mechanical theory of first-order coherence for statistically non-stationary light in the space-frequency domain.

JThB21
Quantum Frequency-Entangled Optical Spread Spectrum for Stealthy Target Detection and Communications, *Jonathan L. Habif[1]; [1]Disruptive Information Processing Technologies Group, Raytheon BBN Technologies, USA.* We describe a transceiver for performing stealthy communication and target detection based on the continuous-variable nature of frequency entanglement that achieves improved detection sensitivity using weak signals in an environment of high noise.

JThB22
Design of Synchronous "Plug & Play" QKD-WDM-PON for Efficient Quantum Communications, *Yi Zhao[1,2], Martin Roetteler[2], Lei Xu[2], Ting Wang[2]; [1]Caltech, USA; [2]NEC Laboratories America, USA.* We propose a new design of quantum key distribution (QKD) - WDM-PON with "plug & play" scheme and synchronization. Simulations show that the design can improve the quantum key generation rate 3-4 times over conventional schemes.

JThB23
Spontaneous Emission from Nanodiamond NV Color Centers on Structured Surfaces, *Faraz A. Inam[1], Torsten Gaebel[1], Carlo Bradac[1], Luke Stewart[2], Michael J. Withford[2], Judith M. Dawes[2], Michael J. Steel[1,2], James R. Rabeau[1,2]; [1]Centre for Quantum Science and Technology, Dept of Physics and Astronomy, Macquarie Univ., Australia; [2]MQ Photonics Research Centre, Dept of Physics and Astronomy, Macquarie Univ., Australia.* We measure distributions of emission rates of single nitrogen vacancy color centers in nanodiamond crystals on distinct surfaces. Comparison to calculations shows emission is strongly influenced by dipole orientation relative to surface interfaces.

JThB24
Polarization Entanglement Generation Based on Birefringence in Polarization Maintained Dispersion Shifted Fiber at 1.5 µm, *Qiang Zhou[1], Wei Zhang[1], Pengxiang Wang[1], Yidong Huang[1], Jiangde Peng[1]; [1]Dept. of Electronic Engineering, Tsinghua National Lab for Information Science and Technology, China.* 1.5 µm polarization entanglement generation is experimentally demonstrated based on birefringence in polarization maintained dispersion shifted fiber. Two-photon interference with visibility of >89% without subtracting background counts is achieved, indicating its polarization entanglement property.

JOINT

JThB • Nonlinear and Quantum Science and Measurements
Joint Poster Session—Continued

JThB25
Twin-Photon Correlated Confocal Microscopy, *David S. Simon[1], Alexander V. Sergienko[1]; [1]Boston Univ., USA.* We introduce two new devices, the correlation confocal and twin-photon microscopes. Like the usual two-photon confocal microscope, they use spatially-correlated photon pairs to improve resolution, but with correlation enforced in different manners.

JThB26
Multipartite entanglement in the optical frequency comb of a depleted-pump optical parametric oscillator, *Reihaneh Shahrokhshahi[1], Olivier Pfister[1]; [1]Physics, Univ. of Virginia, USA.* We study the effect of pump depletion in a single type-I optical parametric oscillator (OPO) and find that pump-mediated, signal-field quantum correlations generate multipartite entanglement in the optical frequency comb of the OPO.

JThB27
Generation of Narrowband Hyperentangled Biphotons, *Shanchao Zhang[1], Jiefei Chen[1], Hui Yan[1], Michael M T Loy[1], George K L Wong[1], Shengwang Du[1]; [1]Dept. of Physics, The Hong Kong Univ. of Science and Technology, Hong Kong.* We generate narrowband hyperentangled nondegenerate paired photons using spontaneous four-wave mixing in cold atoms. The entanglement in both time-frequency and polarization is confirmed by correlation measurements and quantum state tomography.

JThB28
Photon-phonon entanglement in a coupled optomechanical system, *Uzma Akram[1], Gerard J. Milburn[1]; [1]Dept. of Physics, School of Maths and Physics, Univ. of Queensland, Australia.* We consider two coupled optomechanical cavities exploring entanglement between all modes in the collective system. In addition to intra cavity entanglement interestingly we find remarkably robust steady state intercavity photon-phonon entanglement.

CLEO:QELS–Fundamental Science 4: Optical Interactions with Condensed Matter and Ultrafast Phenomena

JThB29
Charge Transport and Ultrafast Localization in Nanocrystalline CdS Films Studied by Optical Pump - Terahertz Probe Spectroscopy, *Zoltan Mics[1], Hynek Nemec[1], Petr Kuzel[1], Petr Maly[2], Petr Nemec[2]; [1]Inst. of Physics, Czech. Acad. Sci., Czech Republic; [2]Faculty of Mathematics and Physics, Charles Univ., Czech Republic.* Terahertz time-resolved conductivity measurements supported by simulations of photocarrier motion provide length scales of the charge localization within nanocrystals and characterize the conductive coupling between them on the ultrafast timescale.

JThB30
Saturation Behaviour of PbSe Nanocrystal Exciton Emission Coupled to Silicon Photonic Crystal Microcavities, *Haijun Qiao[1,2], Charles Foell[1], Keith Abel[3], Stephen Hughes[4], Frank van Veggel[3], Jeff F. Young[1]; [1]Dept. of Physics and Astronomy, Univ. of British Columbia, Canada; [2]Dept. of Chemistry, Simon Fraser Univ., Canada; [3]Dept. of Chemistry, Univ. of Victoria, Canada; [4]Dept. of Physics, Engineering Physics, and Astronomy, Queen's Univ., Canada.* We demonstrate the saturation of non-resonantly pumped, cavity-coupled exciton emission from 5 nm PbSe nanocrystals on silicon photonic crystal microcavities at microwatt excitation powers at room temperature, in agreement with simulations.

JThB31
Thermoelectric Vs. Photoelectric Response of Graphene-Metal Photodetectors, *Haining Wang[1], Jared Strait[1], Farhan Wang[1], Carlos Ruiz-Vargas[2], Jiwoong Park[2]; [1]Electrical and Computer Engineering, Cornell Univ., USA; [2]Chemistry and Chemical Biology, Cornell Univ., USA.* We study the photocurrent in graphene-metal photodetectors. Our results show that the thermoelectric current dominates the photocurrent response.

JThB32
A Quantum-Optical Approach to Carrier Multiplication in Quantum Dots, *Franz Schulze[1], Andreas Knorr[1], Carsten Weber[1]; [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany.* Measurements of carrier multiplication (CM) in quantum dots show promising but also contradictory results. We approach this problem theoretically by identifying relevant signatures of CM in accessible quantum-optical emission spectra.

JThB33
A Proposed Scheme for the Electron and Nuclear Spin Initialization in General Localized Electron Systems, *Toshihide Takagahara[1]; [1]Kyoto Inst. of Technology, Japan.* An efficient scheme is proposed to initialize both the electron and nuclear spins in general localized electron systems via the hyperfine interaction-induced crossing between the singlet and triplet electronic states.

JThB34
Carrier Dynamics Investigation in a Quantum Cascade Laser using Mid-IR Femtosecond Pulses, *Sheng Liu[1,2], Elaine Lalanne[2], Peter Q. Liu[3], Anthony M. Johnson[1,2], Claire F. Gmachl[3]; [1]CASPR, UMBC, USA; [2]Physics, UMBC, USA; [3]Electrical Engineering, Princeton Univ., USA.* In a room temperature 4.5μm QCL resonantly pumped with fs Mid-IR pulses, we observe an ultrafast gain recovery within the first 200fs, gain oscillation within the 1ps and a slower gain recovery of lifetime ~2-3ps.

JThB35
Effects of exchange, phase space filling, and screening on 1s-2p 2D excitonic transitions, *Andrew M. Parks[1], Marc M. Dignam[1]; [1]Dept. of Physics, Engineering Physics and Astronomy, Queen's Univ., Canada.* We study the 1s-2p exciton transition in a quantum well. If the ratio of free carrier to 1s exciton density is greater than 0.15%, screening dominates exchange and phase-space filling, yielding a red shift.

JThB36
Calculations of the two-photon Franz-Keldysh effect and field-induced quantum interference control in GaAs, *Jared Wahlstrand[1,2], Steven T. Cundiff[2], J. E. Sipe[2]; [1]Physics, Univ. of Maryland, USA; [2]JILA, National Inst. of Standards and Technology, USA.* The one- and two-photon Franz-Keldysh effect in bulk GaAs is calculated using a 14-band model for the band structure. Two-photon transitions are found to have a strong polarization dependence.

JThB37
Photoinduced Critical Slowing Down of Femtosecond Hole Spin Relaxation in Ferromagnetic GaMnAs, *Tianqi Li[1], Aaron Patz[1], Ilias E. Perakis[2], Xinyu Liu[3], Jacek Furdyna[3], Jigang Wang[1]; [1]Physics & Astronomy, Iowa State Univ., USA; [2]Physics, Univ. of Crete, Greece; [3]Physics, Univ. of Notre Dame, USA.* We report for the first time photoinduced femtosecond hole spin dynamics and critical behaviors in a ferromagnetic semiconductor, revealing, in particular, a critical slowing down of hole spin relaxation near ferro- to paramagnetic phase transition.

JThB38
Coherent control of phonon localization in ZnTe(110) using femtosecond laser pulses, *Jianbo Hu[1,2], Oleg V. Misochko[3], Kenji Ohmori[2,4], Kazutaka G. Nakamura[1,2]; [1]Materials and Structures Lab, Tokyo Inst. of Technology, Japan; [2]JST-CREST, Japan; [3]Inst. of Solid State Physics, Russian Academy of Sciences, Russian Federation; [4]Inst. of Molecular Science, National Inst. of Natural Science, Japan.* Two-phonon bound states have been impulsively excited via second-order Raman scattering in ZnTe(110) and detected with the pump-probe technique. By using femtosecond laser pulses, we have realized the coherent manipulation of phonon localization.

JThB39
Ultrafast THz Saturable Absorption in Doped Semiconductors, *Dmitry Turchinovich[1], Matthias C. Hoffmann[2]; [1]DTU Fotonik - Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark; [2]Max Planck Research Dept. for Structural Dynamics, CFEL, Univ. of Hamburg, Germany.* We demonstrate ultrafast THz saturable absorption in n-doped semiconductors by nonlinear THz time-domain spectroscopy. This effect is caused by the conductivity modulation due to electron heating and satellite-valley scattering in strong THz fields.

JThB40
Dynamics of Photo-Excited Carriers in Gallium Nitride under Subpicosecond Laser Pulse Excitation, *Sergey Rudin[1], Gregory A. Garrett[1], Michael Wraback[1], Enrico Bellotti[2]; [1]U.S. Army Research Lab, USA; [2]Electrical and Computer Engineering, Boston Univ., USA.* We present a study of subpicosecond kinetics of photo-excited carriers in bulk gallium nitride. The theoretical results are compared with the experimental results of the time-resolved photoluminescence induced by a 100-femtosecond pulse.

JThB • Nonlinear and Quantum Science and Measurements
Joint Poster Session—Continued

JThB41
Time-Resolved x-ray diffraction with polycapillary x-ray optics, *Yuan Gao[1], Matthew DeCamp[1]; [1]Physics and Astronomy, Univ. of Delaware, USA.* Picosecond x-ray diffraction using a quasi-collimating polycapillary optic and a laser plasma based x-ray source is demonstrated, significantly reducing data acquisition time for time-resolved studies.

JThB42
Conical Intersection Dynamics in a Rhodopsin Analog: Isorhodopsin, *Dario Polli[1], Daniele Brida[1], Cristian Manzoni[1], Katelyn M. Spillane[2], Marco Garavelli[3], Philipp Kukura[4], Richard A. Mathies[2], Giulio Cerullo[1]; [1]Politecnico di Milano, Italy; [2]Univ. of California at Berkeley, USA; [3]Università di Bologna, Italy; [4]Oxford Univ., UK.* Using broadband sub-20-fs ultrafast spectroscopy we study the conical intersection dynamics in the visual pigment analog 9-cis Isorhodopsin. We find a longer excited state lifetime and oscillations suggestive of pulsed photoproduct formation.

CLEO:QELS–Fundamental Science 7: High-Field Physics and Attoscience

JThB43
Characterizing isolated atomic unit attosecond pulses, *Michael Chini[1,2], Steve Gilbertson[2], Sabih D. Khan[2], Zenghu Chang[1]; [1]CREOL and Dept. of Physics, Univ. of Central Florida, USA; [2]Dept. of Physics, Kansas State Univ., USA.* Characterizing shorter attosecond pulses has been limited by an approximation in the FROG-CRAB retrieval. We demonstrate a new technique based on interference in laser-assisted photoionization which can characterize ultrabroadband attosecond pulses.

JThB44
Molecular orientation by intense visible and THz optical pulses, *Kenta Kitano[1,2], Nobuhisa Ishii[1,2], Jiro Itatani[1,3]; [1]Inst. for Solid State Physics, Univ. of Tokyo, Japan; [2]CREST, Japan Science and Technology Agency, Japan; [3]PRESTO, Japan Science and Technology Agency, Japan.* We propose an all-optical method for molecular orientation by using intense visible and THz optical pulses. We show numerically that the highest degree of orientation $\langle\cos\theta\rangle \sim 0.6$ in HBr is feasible under experimentally available conditions.

JThB45
Explosions of Xenon Doped Methane Clusters in Intense X-Ray FEL Pulses, *Nirmala Kandadai[1], Kay Hoffmann[1], Heiko Thomas[1], Ahmed Helal[1], John Keto[1], Todd Ditmire[1], Bianca Iwan[2], Nicusor Timneanu[2], Jacob Andreasson[2], Marvin Seibert[2], David van der Spoel[2], Janos Hajdu[2], Sebastian Schorb[3], Tais Gorkhover[3], Daniela Rupp[3], Marcus Adolph[3], Thomas Möller[3], Gillis Doumy[4], Louis F. DimMauro[4], Christoph Bostedt[5], John Bozek[5], Matthias Hoener[6], Brendan Murphy[6], Nora Berrah[6]; [1]The Univ. of Texas at Austin, USA; [2]Uppsala Univ., Sweden; [3]Technische Universität Berlin, Germany; [4]The Ohio State Univ., USA; [5]Stanford Linear Accelerator Center, USA; [6]Western Michigan Univ., USA.* Interaction of ultrashort -X-rays laser with xenon doped methane clusters have been studied in the first experiments at LCLS with time-of-flight technique. Xe doping affects the explosion of the CH_4 clusters.

JThB46
Effects of Inter-Electron Correlation Before Ionization, *Xu Wang[1]; [1]Physics & Astronomy, Univ. of Rochester, USA.* Using a classical ensemble method, we predict that electron-electron correlation before ionization leads to measurable effects in both nonsequential and sequential double ionization regimes. Laser field ellipticity is key to observe these effects.

JThB47
Optimized two-color polarization gating with infrared laser for isolated attosecond pulse generation, *Pengfei Lan[1], Eiji Takahashi[1], Qingbin Zhang[1], Katsumi Midorikawa[1]; [1]RIKEN, Japan.* We proposed and theoretically demonstrated an optimized two-color polarization gating method to produce isolated attosecond pulse by using a multicycle infrared laser pulses with the pulse duration up to 60 fs.

JThB48
Influence of Nonadiabatic Tunneling Ionization on Short-Wavelength-Driven High Harmonic Generation, *Vasileios-Marios Gkortsas[1], Chien-Jen Lai[1], Kyung-Han Hong[1], Siddharth Bhardwaj[1], Edilson Falcão-Filho[1], Franz X. Kaertner[1]; [1]Electrical Engineering and Computer Science, Massachusetts Inst. of Technology, USA.* High harmonic generation efficiency is theoretically modeled and compared with experiments using 400 and 800 nm driver pulses. Our study shows that for short drive wavelengths nonadiabatic tunneling ionization leads to enhanced low order harmonics.

JThB49
Strong-Field Quantum Control of Energy Ladder Climbing, *Sangkyung Lee[1], Jongseok Lim[1], Jaewook Ahn[1]; [1]Physics, KAIST, Republic of Korea.* We demonstrate coherent control of multiphoton absorption in a dynamically shifted energy level structure. In a three-level model of atomic sodium, we controlled the quantum interference of sequential 2 1 photons and direct three-photon transitions.

JThB50
Polarization Dependence of Carbon Fragments from Methane in Strong and Ultrastrong Laser Fields, *Nagitha Ekanayake[1], Bruce Wen[1], Lauren Howard[1], Sarah Wells[1], Michael Videtto[1], Christopher Mancuso[1], Teddy Stanev[1], Zack Condon[1], Sara LeMar[1], Arielle Camilo[1], Rob Toth[1], Matthew DeCamp[1], Barry C. Walker[1]; [1]Univ. of Delaware, USA.* We present the polarization dependence of the ultrafast photoionization for C^{+n} ($n \leq 5$) fragments from methane. The study extends from the strong field (C^{+}, C^{+2}) at 10^{14} W/cm^2 to the ultrastrong field (C^{+5}) at 10^{18} W/cm^2.

JThB51
Two-Color-Laser-Driven Direct Electron Acceleration in Infinite Vacuum, *Liang Jie Wong[1], Franz X. Kaertner[1]; [1]Dept. of Electrical Engineering and Computer Science and Research Lab of Electronics, Massachusetts Inst. of Technology, USA.* We propose a scheme that uses a two-color pulsed radially-polarized laser beam to achieve electron acceleration exceeding 90% of the theoretical energy gain limit, over twice of what is possible with a one-color beam.

CLEO:QELS–Fundamental Science 5: Nonlinear Optics and Novel Phenomena

JThB52
Enhanced surface third harmonic generation in TiO_2 nanolayers, *Susanta K. Das[1], Christoph Schwanke[1], Andreas Pfuch[2,3], Wolfgang Seeber[2], Martin Bock[1], Ruediger Grunwald[1]; [1]Max Born Inst. for Nonlinear Optics and Short-Pulse Spectroscopy, Germany; [2]Otto Schott Inst., Friedrich Schiller Univ., Germany; [3]Innovent e.V., Germany.* Highly efficient surface third harmonics (STHG) in TiO_2 nanolayers was obtained by exciting with 13-fs Ti:sapphire laser pulses. Using a 180 nm thick film, the conversion efficiency exceeded air-glass STHG by a factor of 30.

JThB53
Investigation of Slow, Stop, and Fast Light Based on Polariton Resonances in Boron Nitride, *Da Li[1], Yi Jiang[1], Yujie J. Ding[1]; [1]Electrical & Computer Engineering, Lehigh Univ., USA.* Following our measurement of polariton resonances in boron nitride, we have investigated slow, stop, and fast light behaviors in mid-infrared region.

JThB54
Anti-Stokes Photoluminescence in GaN due to Three-Photon Absorption, *Guan Sun[1], Yujie J. Ding[1]; [1]Electrical & Computer Engineering, Lehigh Univ., USA.* We have observed anti-Stokes photoluminescence from n-type free-standing GaN, pumped at the excitation photon energy of 1.586 eV, due to three-photon absorption.

JThB55
Low-power All-optical Switching via Tunable Coupling of Nanocomposite Photonic Crystal Microcavities, *Xiaoyong Hu[1], Qihuang Gong[1], Zhiqiang Li[1], Hong Yang[1]; [1]Peking Univ., China.* All-optical diode is realized in asymmetric nanocomposite All-optical switching effect is realized based on dynamically tunable coupling of nanocomposite photonic crystal microcavities. The threshold pump photon energy as low as 600 fJ is achieved.

JThB56
Experimental observation of Raman-shifting soliton pairs, *Alexander Hause[1], Philipp Rohrmann[1], Haldor Hartwig[1], Fedor Mitschke[1]; [1]Institut fuer Physik, Universitaet Rostock, Germany.* Two types of fiber-optic soliton pairs in the presence of Raman self-frequency shift were predicted recently. We report experimental observation of one of these types and obtain good quantitative agreement.

JThB57
Calculating the second harmonic near field radiation pattern from a $LiNbO_3$ nanowire using a nonlinear Volume Integral Equation Method, *Ioannis Papadopoulos[1], Ye Pu[1], Demetri Psaltis[1]; [1]School of Engineering, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland.* We propose a novel nonlinear Volume Integral Equation formulation for second harmonic scattering problems, which we use for the calculation of the second harmonic near field generated from $LiNbO_3$ nanowires.

JThB58
Phase-matched second harmonic generation by enhanced nonlinearities in ferroelectric domain walls, *Xuewei Deng[1], Huaijin Ren[1], Xianfeng Chen[1]; [1]Physics Dept., Shanghai Jiao Tong Univ., China.* By employing angle modulation, phase-matched efficient Cherenkov second harmonics can be generated by different domain walls, which is a novel mechanism totally distinguished from Quasi-phase-matching.

JThB59
A strategy to experimentally find bound states of dispersion managed solitons, *Philipp Rohrmann[1], Haldor Hartwig[1], Alexander Hause[1], Fedor Mitschke[1]; [1]Institut fuer Physik, Universitaet Rostock, Germany.* An experimental method to find bound states of dispersion managed solitons is presented. The pulse parameters are optimized with a genetic algorithm in a closed loop. Numerical tests of the method have already been successful.

JThB60
Measuring Vortex Charge With a Triangular Aperture, *Luis de Araujo[1], Matthew E. Anderson[2]; [1]Inst. of Physics, Universidade Estadual de Campinas, Brazil; [2]Dept. of Physics, San Diego State Univ., USA.* We measure the charge of vortex beams (up to ±7) via diffraction in a triangular aperture. We also apply this technique for measuring femtosecond vortices and non-integer vortices. The results compare favorably with numerical modeling.

JThB61
Control of Optical Rogue Waves in Supercontinuum Generation with a Minute Continuous Wave, *Qian Li[1], Chi Zhang[2], Kim K. Y. Cheung[2], Yi Qiu[2], Kevin. K Tsia[2], Kenneth K. Y. Wong[2], Feng Li[1], Alan Pak Tao Lau[1], Ping Kong Alex Wai[1]; [1]The Hong Kong Polytechnic Univ., Hong Kong; [2]The Univ. of Hong Kong, Hong Kong.* We numerically demonstrate that optical rogue wave in supercontinuum generated with picosecond pulse can be controlled by a minute continuous wave.

JThB62
Theory of Faraday effect in high-Q Whispering-Gallery optical cavities, *Shoufeng Lan[1], Mani Hossein-Zadeh[1]; [1]Electrical Engineering, Center for High Technology Materials, Univ. of New Mexico, USA.* The general theory of Faraday rotation in high-Q Whispering-Gallery optical cavities is investigated. We have studied the behavior of the transmission spectrum and identified the optimal condition for maximum sensitivity to external magnetic field.

JThB63
Transversely Stable Soliton Trains in Photonic Lattices, *Jianke Yang[1]; [1]Univ. of Vermont, USA.* We theoretically demonstrate that transverse instability of soliton trains can be completely eliminated by photonic lattices if the soliton trains bifurcate from X points of Bloch bands with saddle-shaped diffraction.

JOINT

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JThB64
Nonelectrical Poling Procedure for ordering NLO dyes in novel host amorphous ferroelectric polymer, *Atsushi Sugita[1], Masashi Morimoto[1], Nobuyuki Mase[1], Yoshimaa Kawata[1], Shigeru Tasaka[1]; [1]Shizuoka Unviersity, Japan.* We will report new strategy for providing second-order NLO activity in host-guest NLO polymers without conventional electrical poling procedure. Formation mechanism of polar order of NLO dyes in amorphous ferroelectric polymers will be shown.

JThB65
Direct Observation of Slow Light in the Noise Spectrum of a Laser, *Abdelkrim El Amili[1], Bernardo-Xavier Miranda[1,2], Fabienne Goldfarb[1], Ghaya Baili[4], Gregoire Beaudoin[3], Isabelle Sagnes[3], Fabien Bretenaker[1], Mehdi Alouini[2,4]; [1]Laboratoire Aimé Cotton CNRS, France; [2]Institut de Physique de Rennes, France; [3]Laboratoire de Photonique et Nanostructures, France; [4]Thales Research and technology, France.* The role of coherent population oscillations is evidenced in the noise spectrum of an ultra-low noise laser. The coherent population oscillations manifest themselves through their associated dispersion probed by the non-lasing side modes.

JThB66
3D OPCPA simulations for a Petawatt class system including nonlinear refractive index effects, *Alexandre Thai[1], Christoph Skrobol[2,3], Philip K. Bates[1], Gunnar Arisholm[4], Zsuzsanna Major[2,3], Ferenc Krausz[2,3], Stefan Karsch[2,3], Jens Biegert[1,5]; [1]ICFO, Spain; [2]Max-Planck-Institut für Quantenoptik, Germany; [3]Ludwig-Maximilians-Universität München, Germany; [4]Forsvarets Forskningsinstitutt, Norway; [5]ICREA-Institució Catalana de Recerca i Estudis Avançats, Spain.* We present 3D OPCPA simulations for 3.67 J, 4 fs transform limited pulses. Including nonlinear refractive index effects reduces the energy by ~11%, increases the transform limit by ~17%, and reduces peak intensity by ~30%.

JThB67
Full Characterization of Tightly Focused Vector Fields through Far Field Third Harmonic Signals, *David Kupka[1], Randy Bartels[1]; [1]Colorado State Univ., USA.* A non-iterative algorithm applied on nanosphere induced far field third harmonic signals capable of retrieving the full vector third order polarization densities and fundamental field at the focal plane is presented.

JThB68
Second Harmonic Generation in Planar Au/Co/Si Structure: Current- and Magneto-Induced Effects., *Sergey I. Mitryukovskiy[1], Oleg A. Aktsipetrov[1], Tatyana V. Murzina[1], Aleksandr I. Stognij[2]; [1]Physics, Lomonosov Moscow State Univ., Russian Federation; [2]Inst. of Solid State and Semiconductor Physics, National Academy of Sciences of Belarus, Belarus.* Second-harmonic generation (SHG) in planar Au/Co/Si nanostructures are studied. Current- and magneto-induced contributions to the SHG signal from cobalt interfaces are observed, and are shown to be comparable with the crystallographic SHG component.

JThB69
The Effects of Spurious Loss/Gain in Numerical Simulations, *Christopher A. Sapiano[1], J. Stewart Aitchison[1], Li Qian[1]; [1]Electrical and Computer Engineering, Univ. of Toronto, Canada.* The effects of spurious loss and gain from error are investigated in numerical simulation of four-wave mixing. Results are compared to previously published results and it is demonstrated that these data suffered from erroneous gain.

JThB70
Low Light-Level Two-Photon Absorption using Tapered Optical Fibers in Rubidium Vapor, *Meimei Lai[1], Scott M. Hendrickson[1], Todd Pittman[1], James Franson[1]; [1]Physics, UMBC, USA.* We describe an experimental observation of two-photon absorption with ultralow power levels of less than 150 nanoWatts. The experiment involves the use of sub-wavelength diameter tapered optical fibers suspended in rubidium vapor.

JThB71
Observation of Optical Phase Amplification in Three Wave Mixing, *Douglas C. French[1], Igor Jovanovic[1]; [1]Mechanical and Nuclear Engineering, The Pennsylvania State Univ., USA.* We present the first measurement of the amplification of optical phase in a phase-sensitive optical parametric amplifier.

JThB72
Equiangular Spiral Tellurite Photonic Crystal Fiber for Supercontinuum Generation in Mid-Infrared, *Yousaf O. Azabi[1], Arti Agrawal[1], B. M. Rahman[1], K. T. Grattan[1], J. Kejalakshmy[1]; [1]School of Engineering and Mathematical Sciences, City Univ., London, UK.* We demonstrate very low and flat dispersion (±2ps/nm/km,slope<0.0028ps/nm^2/km@1.8-2μm) in the Mid-Infrared band along with high non-linear coefficient (γ=1155W^{-1}km^{-1}@1.93μm) achieved in a tellurite photonic crystal fiber for generating supercontinuum.

JThB73
Unidirectional Perfect Transmission Resonances in Nonlinear Asymmetric Photonic Multilayers, *Sergei V. Zhukovsky[1], Andrey G. Smirnov[2]; [1]Dept. of Physics, Univ. of Toronto, Canada; [2]B. I. Stepanov Inst. of Physics, National Academy of Sciences, Belarus.* Unidirectional transmission in asymmetric nonlinear photonic multilayers of the type $(BA)^k(AB)^k(AABB)^m$ with perfect transmission resonances is examined. Optical diode action with >92% transmittance in only one direction is demonstrated numerically.

JThB74
Continuous-wave second harmonic generation of a tunable CO_2 laser in orientation-patterned GaAs, *Leonel P. Gonzalez[1], Derek Upchurch[1], Peter G. Schunemann[2], Lee Mohnkern[2], Shekhar Guha[1]; [1]Air Force Research Lab, USA; [2]BAE Systems, USA.* Frequency doubling of a tunable continuous wave CO_2 laser in orientation-patterned GaAs is demonstrated. For 1.8 W incident power at 9.29 micron, 1.9 mW of second harmonic power was obtained from a 4 cm long crystal.

JThB75
Gold nanoshells for nonlinear plasmonic at telecom wavelengths, *Edilson L. Falcao-Filho[1], R. Barbosa-Silva[2], R. G. Sobral-Filho[2], A. M. Brito-Silva[2], A. Galembeck[3], C. B. de Araújo[1]; [1]Dept.o de Física, Universidade Federal de Pernambuco, Brazil; [2]Programa de Pós-Graduação em Ciência de Materiais, Universidade Federal de Pernambuco, Brazil; [3]Departamento de Química Fundamental, Universidade Federal de Pernambuco, Brazil.* The nonlinear response of silica-gold-nanoshells (SGNS) in chloroform was studied at 1560nm, and an analytical approach that allowed extraction of the third- and the fifth- nonlinear susceptibility of a SGNS from the data is presented.

JThB76
Two-Photon Correlations of Broadband Four Wave Mixing, *Rafi Vered[1], Michael Rosenbluh[1], Avi Peèr[1]; [1]Bar Ilan Univ., Israel.* We experimentally demonstrate the precise time-energy correlation of light generated by ultrabroad four-waves mixing in a photonic crystal fiber. Ultra broadband sum-frequency generation serves as an ultrafast detector of both the time and frequency correlation.

CLEO: Science & Innovations 4: Applications of Nonlinear Optics

JThB77
Compact Representation of Spatial Modes of Phase-Sensitive Image Amplifier, *Muthiah Annamalai[1], Michael Vasilyev[1], Nikolai Stelmakh[1], Prem Kumar[2]; [1]Dept. of Electrical Engineering, Univ. of Texas at Arlington, USA; [2]Dept. of Electrical Engineering and Computer Science, Northwestern Univ., USA.* We compute eigenmodes of spatially-broadband optical parametric amplifier with elliptical Gaussian pump and find compact representation of well-amplified modes by the space of the first few Laguerre- or Hermite-Gaussian modes of appropriate waist.

JThB78
Rigorous Quantification of Polarized Fiber Continuum Generation for Broadband Coherent Optical Sources, *Haohua Tu[1], Yuan Liu[1], Utkarsh Sharma[1], Stephen A. Boppart[1]; [1]Univ. of Illinois at Urbana-Champaign, USA.* We develop a polarized coherent continuum source based on a dispersion-flattened dispersion-decreased all-normal dispersion fiber (DFDD-ANDiF). The rigorous quantification of continuum generation permits broadband ultrashort pulse shaping.

JThB79
Observation of symmetry-breaking beam dynamics in optically induced hexagonal photonic lattices, *Sheng Liu[1], Yi Hu[2], Peng Zhang[3], Xuetao Gan[1], Jianlin Zhao[1], Cibo Lou[2], Daohong Song[2], Zhigang Chen[2,3]; [1]School of Science, Northwestern Polytechnical Univ., China; [2]TEDA Applied Physics School, Nankai Univ., China; [3]Dept. of Physics and Astronomy, San Francisco State Univ., USA.* We study symmetry-breaking of the multi-vortex Bloch modes in optically induced hexagonal lattices. Such symmetry-breaking results from either exciting with an anisotropic beam or inducing an anisotropic photonic lattice.

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JThB80
Synthesis of flat and broadband parametric gain by idler loss in optical fiber, *Hongyao Liu[1], Kun Xu[1], Jian Wu[1], Wei Li[1], Yan Li[1], Xiaobin Hong[1], Yong Zuo[1], Tong J. Lin[1], Yitang Dai[1]; [1]Beijing Univ. of Post and Telecommunication, China.* Besides dispersion engineering, idler-band distributed loss provides a new synthesis freedom to flatten and broaden the gain spectrum for fiber-optic parametric amplifier. The pump-to-signal conversion efficiency is kept high in spite of the loss.

JThB81
Cascaded higher-order soliton compression, *Qian Li[1], J. Kutz[2], Ping Kong Alex Wai[1]; [1]The Hong Kong Polytechnic Univ., Hong Kong; [2]Univ. of Washington, USA.* We theoretically demonstrate high-degree and high-quality optical pulse compression using cascaded higher-order solitons in optical fiber.

JThB82
Non-axial-scanning Second Harmonic Microscopy, *Chuan Yang[1], Kebin Shi[1], Haifeng Li[1], Qian Xu[1], Venkatraman Gopalan[2], Zhiwen Liu[1]; [1]Electrical Engineering, The Pennsylvania State Univ., USA; [2]Material Science and Engineering, The Pennsylvania State Univ., USA.* We demonstrate a chromatic second harmonic imaging technique that exploits the chromatic aberration of a Fresnel lens to focus different wavelengths into different axial positions to effectively realize axial scanning and improve imaging speed.

JThB83
Hyperfine aperiodic optical superlattice optimized by iterative domino algorithm for phase-matching engineering, *Cheng-Wei Hsu[1], Jui-Yu Lai[1], Shang-Da Yang[1]; [1]Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan.* We propose hyperfine aperiodic optical superlattice optimized by iterative domino algorithm to achieve arbitrary discrete and continuous phase-matching power spectra. This scheme improves the record overall efficiency by 9% and handles $>10^5$ blocks.

JThB84
Noise Reduction of Supercontinua via Optical Feedback, *Nicoletta Brauckmann, Michael Kues, Petra Gross, Carsten Cleff, Carsten Fallnich; Inst. of Applied Physics, Westfälische Wilhems-Univ. Münster, Germany.* Noise reduction via optical feedback concerning the pulse energy and spectral amplitude of supercontinua is demonstrated experimentally and numerically by comparing the feedback system with a common single-pass supercontinuum generating system.

JThB85
Time-Domain Analysis of Pulse Propagation in High-Contrast Layered Structures with Resonant Nonlinearities, *Peyman Sarrafi[1], Li Qian[1]; [1]Univ. of Toronto, Canada.* We introduce a generalized time-domain transfer-matrix method, the only method to our knowledge that is capable of modeling high-index-contrast layered structures with non-analytical form of dispersion and slow resonant nonlinearities.

JThB86
Enhanced Two-Photon Absorption in Polycrystalline Silicon, *Karan K. Mehta[1], Jason S. Orcutt[1], Rajeev J. Ram[1]; [1]MIT, USA.* We discuss measurements of the TPA coefficient (β) in polycrystalline silicon deposited in a scaled CMOS process; measurements in thin film, waveguides and microring resonators indicate β is over two orders of magnitude larger than in crystalline Si.

JThB87
Remote gas leak detection using a portable mini-Lidar, based on a doubly-resonant OPO, *Bertrand Hardy[1], Myriam Raybaut[1], Antoine Godard[1], Ajmal K. Mohamed[1], Jean-Michel Melkonian[1], Michel Lefebvre[1]; [1]DMPH, Onera, France.* We report on remote gas leak detection using a portable mini-Lidar. The Lidar transmitter is based on a micro-laser pumped, entangled cavities, doubly-resonant optical parametric oscillator, allowing specific tuning procedures in the 3.8-4.3μm range.

JThB88
Non-Solitonic Extension of Supercontinua, *Ben H. Chapman[1], John C. Travers[1], Sergei Popov[1], Arnaud Mussot[2], Alexandre Kudlinski[2], J. R. Taylor[1]; [1]Femtosecond Optics Group, Imperial College London, UK; [2]Laboratoire de Physique des Lasers, Atomes et Molecules, IRCICA, Universite Lille 1, France.* Four wave mixing of solitons and dispersive waves can extend supercontinua into the long-wavelength normal dispersion region in double zero-dispersion wavelength fibers, where extension through soliton Raman-self-frequency-shift is denied.

JThB89
Broadband, Rapidly Tunable, BiB_3O_6 Femtosecond Optical Parametric Oscillator Directly Pumped by a Ti:sapphire, *Adolfo Esteban-Martin[1], V. Ramaiah Badarla[1], Valentin Petrov[2], Majid Ebrahim-Zadeh[1,3]; [1]ICFO-Institut de Ciencies Fotoniques, Spain; [2]Max-Born-Inst. for Nonlinear Optics and Ultrafast Spectroscopy, Germany; [3]Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report a femtosecond optical parametric oscillator based on BiB_3O_6 pumped directly by a KLM Ti:sapphire laser, providing broad, continuous, and rapid tuning in the near-infrared using cavity delay detuning with self-compressed signal pulses.

JThB90
Hybrid modal-phase-matched and bent-quasi-phase-matched wavelength conversion in AlGaAs/SiO_2 rib-type zigzag waveguides, *Tomonori Matsushita[1], Takashi Kondo[1]; [1]Materials Engineering, The Univ. of Tokyo, Japan.* We propose a novel wavelength conversion device achieving both modal and quasi phase matching in straight and bent waveguides with the laterally inverted core structure. Numerical simulations reveal AlGaAs/SiO_2 rib waveguides are highly efficient.

JThB91
Fiber-Laser-Pumped, High-Power, Continuous-Wave, Mid-Infrared Optical Parametric Oscillator Based on MgO:sPPLT, *S. Chaitanya Kumar[1], Majid Ebrahim-Zadeh[1,2]; [1]Optical Parametric Oscillators, ICFO-The Inst. of Photonic Sciences, Spain; [2]Institucio Catalana de Recerca i Estudis Avancats, Passeig Lluis Companys 23, Spain.* We report a continuous-wave singly-resonant optical parametric oscillator based on MgO:sPPLT pumped by a Yb-fiber-laser, generating up to 5.5W mid-infrared idler power tunable over 430 nm, with peak-peak power stability of 9.7% over 3 hours.

JThB92
Broadband Phase-Matched Backward Difference-Frequency Generation: A Novel Scheme for Spectral Optical Phase Conjugation, *Yi Jiang[1], Da Li[1], Yujie J. Ding[1], Ioulia B. Zotova[2]; [1]Electrical & Computer Engineering, Lehigh Univ., USA; [2]ArkLight, USA.* We have observed broadband quasi-phase-matched backward difference-frequency generation in short-period periodically-poled KTP, which can be used as a novel scheme for spectral phase conjugation.

JThB93
Sum Frequency Generation of 595nm ps-Pulses Based on Er-doped Fiber Amplifier Setup and Seeded by Gain-Switched Laser Diodes, *Kristian Lauritsen[1], Thomas Schoenau[1], Sina Riecke[1], Shirley McNeil[2]; [1]PicoQuant GmbH, Germany; [2]AdvR Inc., USA.* Yellow-orange picosecond pulses are generated via Sum Frequency Generation of 1529nm (pulsed) and 974nm (cw) radiation in a PPKTP waveguide. The pJ-energy pulses around 595nm are freely triggerable up to 80MHz.

JThB94
2D PPLN for Simultaneous Laser Q-switching and Optical Parametric Oscillation in a Nd:YVO_4 Laser, *Yen-Hung Chen[1], Wei-Kun Chang[1], Hsi-Hsiung Chang[1], Jui-Wen Chang[1], Shou-Tai Lin[2,1], Yen-Yin Lin[2,1], Yen-Chieh Huang[2,1]; [1]Dept. of Optics and Photonics, National Central Univ., Taiwan; [2]Inst. of Photonics Technologies, National Tsinghua Univ., Taiwan.* We report a tunable pulsed optical parametric oscillator using a 2D PPLN as simultaneous an electro-optic Bragg Q-switch and a parametric generator in a Nd:YVO_4 laser. >650-W peak-power eye-safe light was obtained with this system.

JThB95
Generation of Continuous-Wave Raman Sidebands through Degenerate and Nondegenerate Intracavity Four-Wave Mixing, *Shin-ichi Zaitsu[1,2], Totaro Imasaka[1,3]; [1]Dept. of Applied Chemistry, Graduate School of Engineering, Kyushu Univ., Japan; [2]PRESTO, Japan Science and Technology Agency, Japan; [3]Division of Translational Research, Center for Future Chemistry, Kyushu Univ., Japan.* The phase-matched intracavity four-wave mixing is controlled by the total dispersion of the optical cavity. Continuous-wave Raman sidebands are generated through three different pathways depending on the phase-matching conditions.

JThB96
Transforming Conventional PPLN-Based Frequency Converters to Cover 13-30 microns: Bridging Gap between Mid-Infrared and Terahertz Regions, *Yujie J. Ding[1]; [1]Electrical & Computer Engineering, Lehigh Univ., USA.* Transverse-pumping geometry can be utilized for efficient generation of far-infrared radiation in 13-30 μm based on difference-frequency generation in periodically-poled $LiNbO_3$ at its polariton resonances. High conversion efficiencies are achievable.

JThB97
Supercontinuum generation in a sapphire fiber and comparison with a compact PCF based light source, *Walter M. Nakaema[1,2], Zuoqiang Hao[1], Philipp Rohwetter[1], Eduardo Landulfo[2], Ludger Woeste[1], Kamil Stelmaszczyk[1]; [1]Inst. of Experimental Physics, Free Univ. of Berlin, Germany; [2]Center for Lasers and Applications, Instituto de Pesquisas Energéticas e Nucleares, Brazil.* A single crystal sapphire fiber pumped with ultrashort laser pulses was used to generate supercontinuum light. Its emission was next compared with this of the PCF based source in terms of the applicability to Multiwavelength-CRD-Spectrography.

JThB98
Geometrical Output Coupling Method of Harmonics in Enhancement Cavities, *Johannes Weitenberg[1], Peter Russbueldt[2], Ioachim Pupeza[3], Hans-Dieter Hoffmann[2], Reinhart Poprawe[1,2]; [1]Lehrstuhl für Lasertechnik, RWTH Aachen Univ., Germany, Germany; [2]Fraunhofer-Institut für Lasertechnik, Germany; [3]Max-Planck-Institut für Quantenoptik, Germany.* Geometrical access to an enhancement cavity is presented, that could be used for output coupling of harmonics. No dispersion or nonlinearity for the fundamental radiation is introduced. Small diffraction losses allow for a finesse >3000.

JThB99
High Efficiency Quasi-Non-Critical Phase-Matched KTiOPO4 Optical Parametric Oscillation, *Xiaodong Mu[1], Helmuth Meissner[1], Huai-Chuan Lee[1], Stephanie Meissner[1]; [1]Onyx Optics Inc, USA.* Quasi-non-critical phase-matched optical parametric oscillation has been achieved in periodically bonded $KTiOPO_4$ stack with a 1.064-μm pump laser. A slope efficiency of 65% has been measured for the total output power of signal and idler.

JThB100
Three-photon counting in a photomultiplier tube for ultrafast source characterization, *Amir Nevet[1], Alex Hayat[1], Meir Orenstein[1]; [1]Electrical Engineering, Technion, Israel.* We demonstrate experimentally ultrafast three-photon counting by three-photon absorption in a photomultiplier tube, which may serve as a unique tool for ultrafast quantum state characterization as well as for ultrasensitive temporal measurements.

JOINT

JThB • Nonlinear and Quantum Science and Measurements
Joint Poster Session—Continued

CLEO: Science & Innovation 5: Terahertz Technologies and Applications

JThB101
Study of the Impedance Mismatch at the End-facet of a Parallel Plate Waveguide Operating in the THz Regime, *Marx Mbonye[1], Rajind Mendis[1], Daniel Mittleman[1]; [1]ECE dept, Rice Univ., USA.* We study the impedance mismatch for terahertz waves propagating in a parallel plate waveguide via the TEM mode. The impedance mismatch is found to be a strong function of the plate separation.

JThB102
Controlling THz Wave Transmission Through Organic Copper Phthalocyanine (CuPc) Films on Si by Optical Excitation, *Hyung Keun Yoo[1], Chul Kang[2], Kiejin Lee[1], Chul-Sik Kee[2], Joong Wook Lee[2]; [1]Physics, Sogang Univ., Republic of Korea; [2]APRI, GIST, Republic of Korea.* We show that transmission of THz waves through an organic copper phthalocyanine (CuPc) film on a Si wafer can be controlled by optical excitation.

JThB103
Application of Metal-clad Antiresonant Reflecting Hollow Waveguides to Tunable Terahertz Notch Filter, *JaYu Lu[1], Hao-Zai Chen[1], Borwen You[1], Chih-Hsien Lai[2], Hung-Chun Chang[2], Tze-An Liu[3], Jin-Long Peng[3]; [1]Inst. of Electro-Optical Science and Engineering , National Cheng Kung Univ., Taiwan; [2]Graduate Inst. of Photonics and Optoelectronics, National Taiwan Univ., Taiwan; [3]Center for Measurement Standards, Industrial Technology Research Inst., Taiwan.* A tunable terahertz notch filter is demonstrated by using antiresonant hollow waveguides. The maximum frequency-tuning-range approached 50% of transmission bandwidth, and a 20dB notch-depth with 6GHz-linewidth was successfully achieved.

JThB104
Temperature dependence of closed mode Q-factor in terahertz metamaterial superlattice, *J. H. Woo[1], Eun Sun Kim[1], Boyoung Kang[1], Eun-Young Choi[1], Hyun-Hee Lee[1], J. H. Kim[1], Y. U. Lee[1], Jeong-Won Wu[1], Jae H. Kim[2], Tae Y. Hong[2]; [1]Dept. of Physics & Quantum Metamaterials Research Center, Ewha Womans Univ., Republic of Korea; [2]Dept. of Physics, Yonsei Univ., Republic of Korea.* Terahertz metamaterial superlattice is fabricated with double-split ring resonators. By cooling down to the cryogenic temperature 4K, changes in Q-factor of closed mode resonance originating from coherent coupling in metamaterial are investigated.

JThB105
Terahertz spectroscopy with focused beams: Gouy shift correction for highly accurate refractive index retrieval, *Christelle Kadlec[1], Hynek Nemec[1], Filip Kadlec[1], Petr Kuzel[1]; [1]Inst. of Physics, Czech Acad. Sci., Czech Republic.* THz measurements are usually performed in focused beam geometry while the standard extraction procedure of the sample refractive index assumes plane-wave approximation. We propose a new retrieval model for spatially limited Gaussian terahertz beams.

JThB106
Quasi-TEM Mode Propagation in Dual-wire THz Waveguide, *Pamela Tannouri[1], Marco Peccianti[1,2], Tsuneyuki Ozaki[1], Roberto Morandotti[1]; [1]INRS-EMT, Canada; [2]IPCF-CNR, Italy.* We demonstrated that Quasi-TEM modes in non-sub-wavelength dual wire THz waveguides (twin lead) can exhibit significant end-fire coupling (>10%) and broad band low dispersion below 1ps^2/m.

JThB107
Narrow Bandgap Semiconductor Based THz-Emitters, *Ingrid Wilke[1], Suranjana Sengupta[1], Partha Dutta[2]; [1]Physics, Applied Physics & Astronomy, Rensselaer Polytechnic Inst., USA; [2]Electrical & Computer & System Engineering, Rensselaer Polytechnic Inst., USA.* The emission of THz-radiation pulses from binary and ternary narrow bandgap semiconductors is discussed. GaxIn1-xAs:Fe is a THz-emitter material for time-domain THz-systems with potentially 1mW of average THz-radiation power at MHz repetition rates.

JThB108
Hybrid Terahertz-Wave Source with Ultrawide-band Tunability utilizing Organic DAST and BNA Crystals, *Takashi Notake[1]; [1]RIKEN, Japan.* Crystal quality of a new nonlinear organic material BNA was much enhanced successfully. A novel hybrid THz-wave source with extremely ultra-wideband frequency tunability was proposed using new BNA and established DAST crystals.

JThB109
Observation of Slow Relaxation on Nano-Confined Water in Nanoporous MCM-41 by Terahertz Spectroscopy, *Yu-Ru Huang[1], Kao-Hsiang Liu[2], Chung-Yuan Mou[2], Chi-Kuang Sun[1,3]; [1]Dept. of Electrical Engineering, Graduate Inst. of Photonics and Optoelectronics, Taiwan; [2]Dept. of Chemistry, Taiwan; [3]Inst. of Physics and Research Center for Applied Sciences, Taiwan.* Interfacial structural and condensed water in nanoporous MCM-41 were investigated by THz-TDS for the first time. A slow reorientation relaxation time of 30 and 100 ps were observed for condensed and structural water.

JThB110
Magnetically controlled broadband THz absorption in a multiferroic hexaferrite at room temperature, *Eiichi Matsubara[1], Yohei Onishi[1], Taishi Ishikura[1], Tsuyoshi Kimura[1], Masaaki Ashida[1,2]; [1]Osaka Univ., Japan; [2]Japan Science and Technology Agency, Japan.* THz time domain spectroscopy reveals the existence of a broad absorption band owing to electromagnons in a multiferroic polycrystal of $Sr_3Co_2Fe_{24}O_{41}$. The absorption can be controlled by weak external magnetic fields.

JThB111
Millimeter-Wave-Band Pulse Formation Using Mach-Zehnder-Modulator-Based Flat Comb Generator, *Isao Morohashi[1], Takahide Sakamoto[1], Tetsuya Kawanishi[1], Iwao Hosako[1]; [1]National Inst. of Infromation and Communications Technology, Japan.* Millimeter-wave-band pulse formation was demonstrated by mixing cw lights and optical pulses extracted from optical comb signals. Millimeter wave pulse with the carrier frequency of 130 GHz and 10 ps-width was observed.

JThB112
Intracavity Widely-Tunable Monochromatic Terahertz-Wave Generation with Organic BNA Crystal and KTP-OPO, *Ming Tang[1], Takashi Notake[1], Yuye Wang[1], Kouji Nawata[1], Hiromasa Ito[1], Hiroaki Minamide[1]; [1]Tera-photonics Lab, RIKEN, Japan.* We demonstrated an efficient intracavity terahertz-wave generation with organic BNA crystal inside a dual-wavelength KTP-OPO cavity. Widely tunable monochromatic terahertz-wave covering 0.9~20 THz has been generated with enhanced pump intensity.

JThB113
Terahertz endoscope based on anti-resonant reflecting hollow core waveguides, *Borwen You[1], Hao-Zai Chen[1], JaYu Lu[1]; [1]Inst. of Electro-Optical Science and Engineering, Taiwan.* A terahertz endoscope utilizing a single plastic hollow-tube with low bending loss is demonstrated to identify molecular concentration and map out object surface-altitudes. The measurements are well consistent with the calculated results.

JThB114
Phase-Slope Measurement of Tunable CW-THz Radiation and Application for Distance Measurement of Optically Rough Object, *Takeshi Yasui[1,2], Makoto Fujio[1], Ryotaro Nakamura[1], Shuko Yokoyama[1], Tsutomu Araki[1]; [1]Grad. Sch. Engg. Sci., Osaka Univ., Japan; [2]Inst. Tech. Sci., Univ. Tokushima, Japan.* We demonstrate phase-slope measurement of tunable CW-THz radiation by photoconductive heterodyne detection with a photocarrier THz comb. Distance of optically rough object is determined from the measured phase-slope within accuracy of 100 μm.

JThB115
Optically Pumped Mixing at 100 GHz with Travelling-Wave Uni-Travelling Carrier Photodiodes, *Efthymios Rouvalis[1], Martyn J. Fice[1], Cyril C. Renaud[1], Alwyn J. Seeds[1]; [1]Electronic and Electrical Engineering, Univ. College London, UK.* Frequency down-conversion Optically Pumped Mixing was performed at 100 GHz with a Travelling-Wave Uni-Travelling Carrier Photodiode. A conversion loss of 40 dB and 54 dB was obtained for fundamental and sub-harmonically pumped mixing respectively.

JThB116
Characterization of THz Beams, *Robert Dickhoff[1], Christian Jastrow[1], Andreas Steiger[1], Ralf Müller[1], Thomas Kleine-Ostmann[1], Thorsten Schrader[1]; [1]Physikalisch-Technische Bundesanstalt, Germany.* Using THz radiation as reliable measurement tool requires the accurate knowledge of beam properties. We present approaches to scan beam profiles and measure the radiation power traceable to SI units between 0.1 and 2.5 THz.

JThB • Nonlinear and Quantum Science and Measurements
Joint Poster Session—Continued

CLEO: Science & Innovations 14: Optical Metrology

JThB117
3D in situ Mapping of Focused Cylindrical Vector Beam Using Trapped Rayleigh Nanoparticles, *Liangcheng Zhou[1], Qiwen Zhan[2], H.Daniel Ou-Yang[1]; [1]Physics, Lehigh Univ., USA; [2]Electro-Optics Graduate Program, Univ. of Dayton, USA.* Optically trapped Rayleigh nanoparticles are used as nanoprobes to map in situ the 3D field distribution of a focused cylindrical vector beam. Intensities calculated from measured trapping energy shows good agreement with numerical simulations.

JThB118
Radial Polarization Interferometer, *Gilad Lerman[1], Uriel Levy[1]; [1]Applied physics, Hebrew Univ. of Jerusalem, Israel.* We demonstrate an interferometer based on interference of radially and azimuthally polarized beams. The spatially varying intensity provides additional information improving phase-change measurements compared with a conventional interferometer.

JThB119
Generation and Tight Focusing of Hybridly Polarized Vector Beams, *Gilad Lerman[1], Liron Stern[1], Uriel Levy[1]; [1]Applied physics, Hebrew Univ. of Jerusalem, Israel.* We demonstrate the generation of hybridly polarized beams. Tight focusing analysis show polarization distribution with 3D orientation and space variant ellipticity, which may be useful for particle orientation analysis, microscopy and atomic systems.

JThB120
Time-of-flight Measurement using Femtosecond Pulses, *Joohyung Lee[1], Young-Jin Kim[1], Seung-Woo Kim[1]; [1]KAIST, Republic of Korea.* We exploit femtosecond pulses for time-of-flight measurement of distances. Not only long distances but also short distances less than 10 m are measured with sub-micrometer precision beyond the traditional limit of time-of-flight measurement.

JThB121
Passive synchronization of repetition and offset frequency between two mode-locked Yb-doped fiber lasers, *Naoya Kuse[1], Yutaka Nomura[1], Akira Ozawa[1], Makoto Kuwata-Gonokami[2], Yohei Kobayashi[1]; [1]The Inst. for Solid State Physics, Univ. of Tokyo, Japan; [2]Dept. of Physics, Univ. of Tokyo, Japan.* We have demonstrated an injection locking of mode-locked Yb-fiber oscillator seeded by another mode-locked pulse train. As well as the repetition rate, the offset frequency of the slave laser was locked passively.

JThB122
High-resolution ^{133}Cs 6S-6D, 6S-8S two-photon spectroscopy using an intra-cavity scheme, *You-Huan Chen[1], Tze-Wei Liu[1], Chien-Ming Wu[1,2], Ray-Kuang Lee[2], Wang-Yau Cheng[1], [1]IAMS, Academia Sinica, Taiwan, [2]Inst. of Photonics Technologies, Natl. Tsing-Hua Univ., Taiwan.* We demonstrate an intra-cavity scheme for diode laser based on two-photon spectroscopy. Three ^{133}Cs hyperfine transition groups of different wavelengths are shown.

JThB123
Achieving Sub-Rayleigh Resolution via Thresholding, *Sara Mouradian[1], Franco Wong[1], Jeffrey H. Shapiro[1]; [1]RLE, Massachusetts Inst. of Technology, USA.* Sub-Rayleigh resolution by a factor proportional to $[\ln(N_{max}/N)]^{1/2}$ is demonstrated through unstructured scanning of a focused classical beam across an object and dynamic application of a threshold N less than the maximum count level N_{max}.

JThB124
Measurements of Pulse Dynamics in Mode-locked Fiber Lasers, *Andrew C. Funk[1], Dale E. Daubendiek[1], Steven Cundiff[1], Curtis Menyuk[2]; [1]JILA, Univ. of Colorado and National Inst. for Standards and Technology, USA; [2]Dept. of Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA.* We present the measurement results of pulse dynamics in a mode-locked Er^{3+} fiber laser. The quantitative data will be useful for determining the noise-limits of optical frequency combs generated by mode-locked fiber lasers.

JThB125
Optical Frequency Comb Using Polarization Maintaining Er-doped Ultrashort Pulse Fiber Laser with Carbon-Nanotube Polyimide Film, *Norihiko Nishizawa[1], Youichi Sakakibara[2,3], Emiko Itoga[2], Hiromichi Kataura[2,3]; [1]Electrical Engineering and Computer Science, Nagoya Univ., Japan; [2]AIST, Japan; [3]JST-CREST, Japan.* Fiber based optical frequency comb was developed using polarization maintaining Er-doped ultrashort pulse fiber laser using polyimide film dispersed with single wall carbon nanotube. fceo was stable and locked with EO modulator and LD driver.

JThB126
Noise reduction of a Carbon Nanotube Fiber Laser Frequency Comb, *Jinkang Lim[1], Brian R. Washburn[1]; [1]Physics, Kansas State Univ., USA.* We report the reduction of noise in a carbon nanotube fiber laser frequency comb using pump attenuation and phase-lead compensation. The measured f0 linewidth was decreased by a factor of four.

JThB127
Characterization of the RIN-to-Phase-Noise Conversion in the Microwave Synthesis from Mode-locked Lasers, *Kan Wu[1], Chunmei Ouyang[1], Jia Huar Wong[1], Perry Shum[1]; [1]Nanyang Technological Univ., Singapore.* The noise conversion from the relative intensity noise to the phase noise in the microwave synthesis (photodetection process) from mode-locked lasers is investigated and is found to decrease as 1/f with the noise frequency.

JThB128
Picometer calibrator for precision linear encoder using a laser interferometer, *Mariko Kajima[1], Kaoru Minoshima[1]; [1]National Inst. of Advanced Industrial Science and Technology(AIST), Japan.* A calibration system for precision linear encoders was developed. This system evaluated interpolation errors with an expanded uncertainty of 0.55 nm (k=2). A commercial laser interferometer was calibrated, and its cyclic error was evaluated.

JThB129
2THz Optical Waveform Measurement by Development of Digital Holographic Synthesizer & Analyzer of 400GHz Optical Frequency Comb, *Toshiaki Yamazaki[1], Hiroshi Ono[1], Tatsutoshi Shioda[1]; [1]Nagaoka Univ. of Technology, Japan.* Optical complex electric field spectra of a 400 GHz optical frequency comb were controlled by a colorless optical synthesizer. The synthesized 2 THz high-speed optical waveform was measured by a proposed multi-heterodyne mixing method.

JThB130
Methods Towards Achieving Precise Birefringent Focusing, *David Schmid[1], Shiraz Hazrat[1], Radhika Rangarajan[1], Onur Hosten[1], Stephan Quint[2], Paul Kwiat[1]; [1]Physics, Univ. of Illinois at Urbana-Champaign, USA; [2]Institut fuer Experimentalphysik, Austria.* We present two independent schemes for the precise focusing of orthogonal polarizations of light at arbitrary relative locations. The first scheme uses a polarization Sagnac interferometer, the second a set of three birefringent elements.

JThB131
Generating an ultra-stable microwave in the drop tower, *Andreas Resch[1], Claus Lämmerzahl[1], Sven Herrmann[1]; [1]FB04, ZARM, Universität Bremen, Germany.* In this work we present our efforts to build a drop tower compatible setup to generate an ultra-stable microwave signal, which is used for the Raman beams in an atom interferometer.

CLEO: Science & Innovations 13: Active Optical Sensing

• *Fiber-Based Sensors*

JThB132
Ultracompact monolithic broadband in-line micro interferometric sensor based on multi-beam interference, *Nan-Kuang Chen[1,2], Kuan-Yi Lu[1], Jow-Tsong Shy[3], Chinlon Lin[4], Sien Chi[5]; [1]Dept. of Electro-Optical Engineering, National United Univ., Taiwan; [2]Optoelectronics Research Center, National United Univ., Taiwan; [3]Dept. of Physics, National Tsing Hua Univ., Taiwan; [4]Bell Lab and Bellcore, Retired, USA; [5]Dept. of Photonic Engineering, Yuan Ze Univ., Taiwan.* We demonstrate broadband micro interferometric sensor based on multi-beam interference using a singlemode fiber end-spliced with an end-sphered hollow-core fiber lens. The length of sensor head is less than 240μm and displacement resolution is 0.8nm.

JThB133
High sensitivity temperature sensor based on Bragg grating in micro/nanofiber, *Jianghai Wo[2,1], Ruibing Liang[2,1], Qizhen Sun[2,1], Deming Liu[2,1]; [1]College of OptoelectronicScience and Engineering, Huazhong Univ. of Science and Technology, China; [2]National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China.* A novel temperature sensor based on fiber Bragg grating (FBG) in micro/nanofiber (MNF) immerged in the refractive index oil with high thermo-optic coefficient is proposed and simulated. A sensitivity of 0.4168nm/C can be achieved.

JThB134
A distributed sensing system based on low-index Bragg reflective fiber gratings, *Manliang Zhang[1], Zi Wang[1], Qizhen Sun[1]; [1]College of Optoelectronic Science and Engineering, Huazhong Univ. of Science and Technology, China.* A sensing scheme based on fiber low-index Bragg gratings is proposed, which utilizes tunable laser to demodulate the wavelength signal. Related experiment is done to investigate.

JThB135
Fiber-optic range sensing based on amplified spontaneous emission noise radar with Kramers-Kronig phase retrieval, *David Mermelstein[1], Moran Biton[1], Shmuel Sternklar[1], Erel Granot[1]; [1]Ariel Univ. Center, Israel.* Amplified spontaneous emission is used as an optical noise source for range sensing. A depth resolution of 30cm and detection of multiple targets is achieved at a range of 2km, using novel Kramers-Kronig algorithms.

JThB136
A Fast Response Photonic Crystal Fiber Grating Refractometer with a Side-opening Structure, *Guanjun Wang[1], Jiansheng Liu[1], Zheng Zheng[1], Yi Yang[2], Jing Xiao[1], Yusheng Bian[1]; [1]School of Electronic and Information Engineering, Beihang Univ., China; [2]College of Information Science and Technology, Donghua Univ., China.* A photonic crystal fiber grating refractometer with a side-opening structure is proposed and studied, which can achieve real time response, minimal refractive index resolution of $1.32x10^{-5}$ R.I.U and high efficient grating writing.

JThB137
A Comparative Study of Raman Enhancement in Capillaries, *Fatemeh Eftekhari[1], Amr S. Helmy[1]; [1]Univ. of Toronto, Canada.* This work reports on the comparative studies of Raman enhancement in hollow core photonic crystal fibers and conventional Teflon capillary tubes theoretically and experimentally.

NOTES

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

14:30–16:15
QThK • Tunable and Fluid Metamaterials
Hatice Altug, Boston Univ., USA, Presider

QThK1 • 14:30
Tuning the Resonance in Superconducting Terahertz Metamaterials, *Hou-Tong Chen[1], Hao Yang[1], Ranjan Singh[1], Abul Azad[1], John F. O'Hara[1], Stuart Trugman[1], Quanxi Jia[1], Antoinette J. Taylor[1]; [1]Center for Integrated Technologies, Los Alamos National Lab, USA.* We report tunable resonances in terahertz metamaterials made from high-temperature superconducting films. Taking in account the temperature-dependent complex conductivity, we develop a theoretical model for correct interpretation of the observed resonance switching and frequency tuning.

QThK2 • 14:45
Reconfigurable Photonic Metamaterials, *Jun-Yu Ou[1], Eric Plum[1], Liudi Jiang[2], Nikolay I. Zheludev[1]; [1]Optoelectronic Research Centre, Univ. of Southampton, UK; [2]School of Engineering Sciences, Univ. of Southampton, UK.* We demonstrate the first temperature driven mechanically reconfigurable photonic metamaterials (RPMs) providing tunability at optical frequencies.

QThK3 • 15:00
Dynamic tunability of the electric dipole resonance in highly photo-excited metamaterials, *Ioannis Chatzakis[1], Liang Luo[1], Jigang Wang[1], Nianhai Shen[1], Thomas Koscny[1], Costas M. Soukoulis[1]; [1]Physics and Astronomy, Iowa State Univ. and Ames Lab, USA.* Using optical-pump THz-probe spectroscopy, we observe a non-monotonic variation in the electric dipole oscillator strength as function of pump fluence, revealing particularly, a partial recovery of the oscillator in highly-excited metamaterials.

QThK4 • 15:15
Terahertz superconducting plasmonics and metamaterials, *Ranjan Singh[2,1], Zhen Tian[2,3], Jianqiang Gu[2,3], Judy Wu[4], Jingwen W. Zhang[5], Weili Zhang[2,3]; [1]CINT, Los Alamos National Lab, USA; [2]School of Electrical and Computer Engineering, Oklahoma State Univ., USA; [3]Center for Terahertz waves and College of Precision Instrument and Optoelectronics Engineering, Tianjin Univ., China; [4]Dept. of Physics and Astronomy, Univ. of Kansas, USA; [5]Dept. of Physics, Harbin Inst. of Technology, China.* We demonstrate a superconductor array of subwavelength holes and split ring resonators with active thermal control over their resonant transmission. The arrays were lithographically fabricated on high temperature YBCO superconductor.

14:30–16:15
CThQ • Nanophotonic Sensors
Lan Yang, Washington Univ., USA, Presider

CThQ1 • 14:30
Photonic crystal enhanced fluorescence using a quartz substrate to reduce limits of detection, *Anusha Pokhriyal[1], Meng Lu[3], Vikram Chaudhery[2], Cheng-Sheng Huang[2], Stephen Schulz[3], Brian T. Cunningham[2,4]; [1]Dept. of Physics, Univ. of Illinois at Urbana-Champaign, USA; [2]Dept. of Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA; [3]SRU Biosystems, USA; [4]Dept. of Bioengineering, Univ. of Illinois at Urbana-Champaign, USA.* Signal enhancement factor of 7500× is shown for detection of LD-700 dye spin-coated upon a Photonic crystal surface. SNR improvement of 330× is shown for the detection of spotted Alexa-647 labeled polypeptide on the PC.

CThQ2 • 14:45
High sensitivity miniature Mach-Zehnder-interferometer using micro-abrupt-tapers in a cladding-depressed strongly guiding fiber for a picoliter-volume microsensing, *Nan-Kuang Chen[1,2], Zhi-Zheng Feng[1], Tsung-Hsun Yang[1], Yi-Ning Chen[1,2], Chinlon Lin[3]; [1]Dept. of Electro-Optical Engineering, National United Univ., Taiwan; [2]Optoelectronics Research Center, Taiwan; [3]Bell Lab and Bellcore, Retired, USA.* We demonstrate miniature Mach-Zehnder-interferometer with device length of 179.5μm using micro-abrupt-tapers in a cladding-depressed strongly-guiding fiber. The index variation of 0.002 from a 6.3 pL optical liquid can cause 1.6nm wavelength-shift.

CThQ3 • 15:00
Optimization of Defect Hole Placement in Resonant Cavity Sensors, *Christopher Kang[1], Christopher T. Phare[1], Yurii A. Vlasov[2], Solomon Assefa[2], Sharon M. Weiss[1]; [1]Vanderbilt Univ., USA; [2]IBM T.J. Watson Research Center, USA.* We demonstrate the resonance wavelength and quality factor dependence of 50nm defect-hole placement within photonic crystal L3 microcavities. Proper placement of defect-holes leads to a 12% increase in photonic crystal sensor detection sensitivity.

CThQ4 • 15:15
A Novel Mechano-Optical Sensor based on Read-out with a Si_3N_4 Grated Waveguide, *S.v. Pham[1], M. Dijkstra[1], Henk van Wolferen[2], Markus Pollnau[1], G.j.m. Krijnen[2], H.j.w.m. Hoekstra[1]; [1]IOMS, MESA+, Univ. of Twente, Netherlands; [2]TST, MESA+, Univ. of Twente, Netherlands.* A proof-of-concept study is reported on fabrication and characterization of a novel and compact integrated mechano-optical sensor based-on a micro-bridge suspended above a Si_3N_4 grated waveguide.

14:30–16:15
CThR • Novel Applications of Nonlinear Optics
Narasimha Prasad, NASA Langley Res. Ctr., USA, Presider

CThR1 • 14:30 Tutorial
Slow Light, Fast Light, and their Applications, *Robert W. Boyd[1,2]; [1]Dept. of Physics, Univ. of Ottawa, Canada; [2]Inst. of Optics, Univ. of Rochester, USA.* We provide a brief overview of the field of slow and fast light. We then describe some of the applications of slow light that have been and are currently being developed.

Robert Boyd received his undergraduate degree from MIT and his PhD from the Univ. of California at Berkeley under the supervision of Charles Townes. He joined the faculty of the Univ. of Rochester and in 2001 became the M. Parker Givens Professor of Optics and Professor of Physics. In 2010 he became Professor of Physics and Canada Excellence Research Chair in Quantum Nonlinear Optics at the Univ. of Ottawa. His research interests include studies of "slow" and "fast" light propagation, quantum imaging techniques, nonlinear optical interactions, studies of the nonlinear optical properties of materials, and the development of photonic devices including photonic biosensors.

14:30–16:15
CThS • CLEO Symposium on Broadband Spectroscopy: New Techniques and Sources II: Spectroscopic Experiments
Nathan Newbury, NIST, USA, Presider

CThS1 • 14:30 Invited
Broadband Direct Frequency Comb Spectroscopy in the Mid-Infrared, *Piotr Maslowski[1], Aleksandra Foltynowicz[1], Florian Adler[1], Kevin C. Cossel[1], Travis Briles[1], Ticijana Ban[1], Jun Ye[1]; [1]JILA, NIST, Univ. of Colorado, USA.* Frequency-comb-based Fourier transform spectrometer operating in the 2100-3600 cm-1 range is presented. System allows rapid acquisition of broadband high resolution (120 MHz) spectra, detecting ppb-level concentrations of various molecules in 30s.

CThS2 • 15:00 Invited
Probing sensitivity limits by comb-based spectroscopic techniques, *Paolo De Natale[1,3], Iacopo Galli[1,3], Davide Mazzotti[1,3], Giovanni Giusfredi[1,3], Pablo Cancio[1,3], Gianluca Gagliardi[2,3], Pasquale Maddaloni[2,3]; [1]INO, CNR, Italy; [2]INO, CNR, Italy; [3]LENS, Italy.* We report on new concepts of comb-based coherent sources that we apply to high-sensitivity measurements of physical quantities, e.g. trace gas concentration and mechanical strain, through different spectroscopic techniques.

Thank you for attending CLEO: 2011. Look for your post-conference survey via email and let us know your thoughts on the program.

CLEO: Science & Innovations

14:30–16:15
CThT • Gas Phase Sensing I
Thomas Reichardt, Sandia Natl. Labs, USA, Presider

CThT1 • 14:30 Invited
Low Cost Absorption Sensors for Networked Applications, *Mark G. Allen[1]; [1]Physical Sciences Inc., USA.* This paper highlights recent work by the authors using mid-IR sources that target two emerging market segments for monitoring major atmospheric species.

CThT2 • 15:00
Ultra-sensitive Faraday Rotation Spectroscopy of O2: Model vs. Experiment, *Stephen So[1], Oscar Marchat[1,2], Evan Jeng[1,3], Gerard Wysocki[1]; [1]Electrical Engineering, Princeton Univ., USA; [2]Physics Dept., ETH Zurich, Switzerland; [3]Electrical Engineering, Stanford Univ., USA.* We compare theoretical model simulations based on the HITRAN database with experimental data for the sensing of O2 using novel balanced Herriott multipass Faraday Rotation Spectroscopy. A detection limit of 10 ppm is achieved.

CThT3 • 15:15
Mid-infrared absorption microscopy with λ/100 spatial resolution using tunable quantum cascade lasers, *Feng Lu[1], Mikhail Belkin[1]; [1]Dept. of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA.* Highly-sensitive mid-IR microscopy is reported. Subwavelength resolution is achieved by detecting absorption via local expansion. High sensitivity is obtained by moving laser pulses repetition rate in resonance with AFM cantilever eigenfrequency.

14:30–16:15
CThU • Fiber Amplifiers and Lasers
Norihiko Nishizawa, Nagoya Univ., Japan, Presider

CThU1 • 14:30
Amplifier Similaritons in a Fiber Laser, *William Renninger[1], Andy Chong[1], Frank Wise[1]; [1]Applied Physics, Cornell Univ., USA.* Parabolic self-similar pulses in an amplifier are realized within a fiber oscillator. In addition to its fundamental importance, this new mode-locking regime offers ultrashort pulse durations from highly normal-dispersion sources.

CThU2 • 14:45
Stimulated Raman Scattering in Chirped-Pulse Amplification: the Role of Vibrational Dephasing, *Simon Lefrancois[1], Frank Wise[1]; [1]Applied Physics, Cornell Univ., USA.* We numerically study the properties of Raman Stokes pulses generated in fiber chirped-pulse amplification. Pulses are compressible for Raman dephasing times as short as a hundredth of the pump pulse duration.

CThU3 • 15:00
High gain fiber optical parametric chirped pulse amplification of femtosecond pulses at 1 μm fiber, *Damien Bigourd[1], Laure Lago[1,2], Arnaud Mussot[2], Alexandre Kudlinski[2], Emmanuel Hugonnot[1]; [1]Commissariat à l'Énergie Atomique et aux Energies Alternatives, CESTA, France; [2]Université des Sciences et Technologies de Lille, IRCICA, FR CNRS 3024, Laboratoire PhLAM, UMR CNRS 8523, France.* Fiber-based OPCPA is reported in the femtosecond regime at 1 μm. A highly stretched signal has been amplified in a microstructured fiber with more than 30 dB gain by an all-fiber pulsed pump.

CThU4 • 15:15
Fast Swept-Source Generation Based on Fiber Optical Parametric Amplifier, *Chi Zhang[1], Kim K. Y. Cheung[1], Po Ching Chui[1], Kevin. K Tsia[1], Kenneth K. Y. Wong[1]; [1]Dept. of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong.* We experimentally demonstrate a fast frequency swept-source using the dispersive Fourier transformation-based fiber optical parametric amplifier. The swept rate is as high as 78 MHz, with a linewidth of 0.135 nm.

14:30–16:15
CThV • THz Imaging
Daniel Mittleman, Rice Univ., USA, Presider

CThV1 • 14:30
Towards a real-time electro-optical THz microscope using a demodulating optical detector array, *Gunnar Spickermann[1], Peter Haring Bolívar[1]; [1]High Frequency and Quantum Electronics, Univ. of Siegen, Germany.* We present an electro-optical THz-Microscope with parallel readout of 3072 pixels. The use of a demodulating detector array increases the efficiency of the setup enabling the use of a non-amplified fs-laser for electro-optic detection.

CThV2 • 14:45
Space-time features of THz emission from optical rectification in sub-wavelength areas, *Sze Phing Ho[1,4], Marco Peccianti[1,2], Fabrizio Buccheri[1-3], Matteo Clerici[1], Alessandro Busacca[3], Tsuneyuki Ozaki[1], Jalil Ali[4], Roberto Morandotti[1]; [1]INRS Énergie, Matériaux et Télécommunications, Canada; [2]IPCF-CNR, UOS Rome, Italy; [3]DIEET, Univ. of Palermo, Italy; [4]Nanophotonics Research Alliance, Universiti Teknologi Malaysia, Malaysia.* We present our investigation on the THz space-time emission characteristic induced by the non-paraxial generation regime in highly localized THz generation via optical rectification on sub-wavelength areas.

CThV3 • 15:00
Characterization of Dodecane-Surfactant-Brine Emulsions Using THz Imaging, *Daniel V. Nickel[1], Jonathan P. Laib[1], Daniel Mittleman[1], Reinaldo Navarrete[2], Jeremy Pearce[2], Paul Tortorici[2]; [1]Rice Univ., USA; [2]Shell, USA.* We investigate the feasibility of using terahertz imaging to quantify the relative dodecane ($C_{12}H_{26}$) content and long-term stability of dodecane-surfactant-brine emulsions of varying salinity for their use in surfactant-enhanced oil recovery.

CThV4 • 15:15
Imaging of Terahertz surface plasmon waves with a sub-wavelength aperture probe, *Raimund Mueckstein[1], Oleg Mitrofanov[1]; [1]Electronic & Electrical Engineering, Univ. College London, UK.* We present imaging of THz surface plasmon polariton (SPP) waves with an integrated sub-wavelength aperture probe. Using detected SPP patterns, we explain the mechanism of SPP coupling into the probe.

CLEO: QELS Fundamental Science

14:30–16:15
QThL • Positioning, Coupling and Focusing in Nanophotonic Systems
Presider to Be Announced

QThL1 • 14:30
On-Chip Focusing of Light by Metallic Nanotip, *Boris Desiatov[1], Ilya Goykhman[1], Uriel Levy[1]; [1]Applied Physics, Hebrew Univ., Israel.* We present a numerical simulations, fabrication and experimental results for on-chip focusing of surface plasmon polaritons (SPPs) in metal nanotip coupled to the silicon waveguide.

QThL2 • 14:45
Polymer Plasmonic Microring Resonators Based on Conductor-Gap-Dielectric Waveguides, *Cameron Horvath[1], Daniel Bachman[1], Marcelo Wu[1], David Perron[1], Vien Van[1]; [1]Electrical and Computer Engineering, Univ. of Alberta, Canada.* We report the first experimental realization of conductor-gap-dielectric plasmonic waveguides based on a SU-8 material system with propagation length of 62μm. Compact plasmonic microring resonators are also demonstrated with high intrinsic Q-factor.

QThL3 • 15:00
Using Local Fields to Tailor Hybrid Quantum Dot-Metal Nanoparticle Systems: Connecting the Dots, *Garnett W. Bryant[1], Ryan D. Artuso[2], Aitzol Garcia-Etxarri[3], Javier Aizpurua[3]; [1]Joint Quantum Inst. and Atomic Physics Division, NIST, USA; [2]Joint Quantum Inst. and Dept. of Physics, Univ. of Maryland, USA; [3]Donostia International Physics Center and Centro de Fisica de Materiales, Spain.* We study systems of metal nanoparticles (MNP) coupled with semiconducting quantum dots (SQD). Hybrid behavior can be tailored by the MNP shape and the exciton resonance of SQDs which determine the local fields.

QThL4 • 15:15
Optical Forces in Scanning Probe Microscopy, *Dana Kohlgraf-Owens[1], Sergey Sukhov[1], Aristide Dogariu[1]; [1]CREOL, Univ. of Central Florida, USA.* We demonstrate that the mechanical action of light can be detected by a scanning probe microscope. The conservative and nonconservative electromagnetic forces can be directly measured and they affect the perceived topography.

CLEO: Science & Innovations

14:30–16:15
CThW • Advances in Biological Microscopy
Siavash Yazdanfar, GE Global Res., USA, Presider

CThW1 • 14:30
Nomarski Serial Time-Encoded Amplified Microscope for High Throughput Imaging of Transparent Media, *Ali Fard[1,2], Ata Mahjoubfar[1,2], Keisuke Goda[1,2], Bahram Jalali[1,2]; [1]Dept. of Electrical Engineering, Univ. of California Los Angeles, USA; [2]California NanoSystems Inst., USA.* We report a new method of high-contrast imaging of unstained and transparent objects at ~1000 times higher frame rates than conventional methods. As a proof-of-concept, we demonstrate enhanced image-contrast in 2D imaging of a transmission grating.

CThW2 • 14:45
Multiplexed Fluorescence Lifetime Microscopy by Frequency-Sweeping Fourier Spectroscopy, *Ming Zhao[1], Leilei Peng[1]; [1]College of Optical Sciences, The Univ. of Arizona, USA.* We developed a multiplexed fluorescence lifetime confocal microscopy method based on frequency sweeping Fourier fluorescence lifetime spectroscopy. It simultaneously obtains nanosecond fluorescence lifetime images at multiple excitation wavelengths.

CThW3 • 15:00 Invited
Fluorescence Nanoscopy: Eluding the Diffraction Limit by Switching Markers, *Andreas Schoenle[1], Stefan W. Hell[1]; [1]NanoBiophotonics, MPI for Biophysical Chemistry, Germany.* By transiently confining adjacent emitters to different states the diffraction limit in light microscopy can be overcome. We will discuss this fundamental concept underlying all current far-field nanoscopy approaches and present recent applications.

CThW4 • 15:30
Double-Helix 3D Photo-activation Localization Microscopy with a Phase Mask for Efficient Photon Collection, *Ginni Grover[1], Sean Quirin[1], Rafael Piestun[1]; [1]Dept. of Electrical, Computer and Energy Engineering, Univ. of Colorado, Boulder, USA.* We demonstrate 3D photo-activation localization microscopy of 4μm thick samples with efficient photon collection using a phase mask fabricated by gray-level lithography. The performance limits of the system in the presence of noise are analyzed.

CLEO: QELS Fundamental Science

14:30–16:15
QThM • Quantum Optics in Cavities and Waveguides
Glenn Solomon, Joint Quantum Inst., USA, Presider

QThM1 • 14:30
Optomechanically Induced Transparency, *Albert Schliesser[1,2], Stefan Weis[1,2], Samuel Deléglise[1,2], Rémi Rivière[2], Emanuel Gavartin[1], Olivier Arcizet[3], Tobias Kippenberg[1,2]; [1]Ecole Polytechnique Fédérale de Lausanne, Switzerland; [2]Max-Planck-Institut für Quantenoptik, Germany; [3]Institut Neél, France.* In analogy to electromagnetically induced transparency observed in atomic systems, we demonstrate that the transmission of a probe laser beam through an optomechanical device can be modulated all-optically using a second, "control" laser beam.

QThM2 • 14:45
Measuring nanomechanical motion with an imprecision below that at the standard quantum limit, *Georg Anetsberger[2], Pierre Verlot[1], Emanuel Gavartin[1], Olivier Arcizet[3], Quirin Unterreithmeier[4], Eva M. Weig[4], Michael L. Gorodetsky[5], Jörg P. Kotthaus[4], Tobias Kippenberg[1]; [1]Sciences de base, EPFL, Switzerland; [2]Max-Planck-Institut für Quantenoptik, Germany; [3]Institut Néel, France; [4]Fakultät für Physik and Center for NanoScience (CeNS),, Ludwig-Maximilians-Universität (LMU), Germany; [5]Dept. of Physics, Moscow State Univ., Germany.* We report an optomechanical near-field coupling detection scheme which enabled the first optical measurement of nanomechanical motion with an imprecision 3 dB below that at the standard quantum limit at room temperature.

QThM3 • 15:00
Resolved Sideband Laser Cooling of a Cryogenic Micromechanical Membrane, *Andrew Jayich[1], Jack Sankey[1], Andrei Petrenko[1], Jack Harris[1,2]; [1]Physics Dept., Yale Univ., USA; [2]Applied Physics Dept., Yale Univ., USA.* We have implemented an optomechanical system consisting of a high finesse cavity centered on a low reflectivity, high mechanical quality factor SiN membrane at a temperature of 400 mK.

QThM4 • 15:15
On-Chip Single Crystal Diamond Resonators, *Birgit J. Hausmann[1], Jennifer Choy[1], Thomas Babinec[1], Qimin Quan[1], Murray W. McCutcheon[1], Patrick Maletinsky[2], Amir Yacoby[2], Marko Loncar[1]; [1]SEAS, Harvard Univ., USA; [2]Physics, Harvard Univ., USA.* We present a fabrication method for diamond based resonators. Optical characterization of a diamond ring resonator on quartz substrate reveals cavity modes both in the telecom and the visible wavelength regime having with Q-factors ~8000.

CLEO: Science & Innovations

14:30–16:15
CThX • Fiber Transmission
Bert Basch, Verizon Labs, USA, Presider

CThX1 • 14:30
Frequency Domain PMD Monitoring and Compensation in High-Speed Coherent Systems with Digital Signal Processing, *Junyi Wang[1], Xuan He[1], Kailu Gao[1], Zhongqi Pan[1]; [1]EECE, Univ. of Louisiana at Lafayette, USA.* We proposed a PMD monitoring/compensation method in frequency domain for coherent system. With 15 ps of average DGD, the PMD induced penalty for 100-Gbit/s QPSK system is reduced by 9 dB at symbol-error-ratio of 10^{-3}.

CThX2 • 14:45
Practical 4-Stage Optical PMD Compensator for Mitigating First- and Second-Order PMD on 40-Gbit/s RZ-D(Q)PSK, *Jeng-Yuan Yang[1], X. Steve Yao[2], Jian Wang[1], X. Chen[2], Lei Dong[2], Leon Yao[1], Alan E. Willner[1]; [1]Dept. of Electrical Engineering, Univ. of Southern California, USA; [2]General Photonics, USA.* A first practical 4-stage compensator with ~1-ms response-time is demonstrated for mitigating first/second order PMD on 40-Gbit/s RZ-D(Q)PSK. BER/DOP are significantly improved and <0.5-dB power-penalty is achieved under 25-ps-DGD and 400-ps^2-SOPMD.

CThX3 • 15:00
Distance limitations on the entanglement distribution over optical fiber due to chromatic and polarization mode dispersion., *Cristian Antonelli[1], Mark Shtaif[2], Misha Brodsky[3]; [1]Univ. of L'Aquila, Italy; [2]Tel Aviv Univ., Israel; [3]AT&T Labs, USA.* We compare bounds to the reach of potential fiber-optic quantum cryptography systems based on entanglement distribution. We find that polarization mode dispersion limits the transmission for systems deployed over lower dispersion fibers such as NZDSF.

CThX4 • 15:15
A Chromatic Dispersion Estimation Method for Arbitrary Modulation Formats, *John Zweck[1], Curtis Menyuk[2]; [1]Mathematics and Statistics, Univ. of Maryland Baltimore County, USA; [2]Computer Science and Electrical Engineering, Univ. of Maryland Baltimore County, USA.* Simulations show that a modulation-format-independent method for estimating chromatic dispersion from the phase of a coherently-received signal at four frequencies can estimate 3000 ps/nm of dispersion to within 2% at an OSNR of 10 dB.

CLEO: QELS-Fundamental Science

14:30–16:15
QThN • Quantum Photonics
Bahaa Saleh, Univ. of Central Florida, USA, Presider

QThN1 • 14:30 Invited

NOON States, *Yaron Silberberg Weizmann Inst. of Science, Israel.* 'High-NOON' states were generated by multiphoton interference of 'quantum' downconverted light with a 'classical' coherent state. Super-resolving phase measurements with up to five entangled photons were demonstrated with a visibility higher than obtainable without entanglement.

QThN2 • 15:00

Type-0 Spontaneous Parametric Down Conversion in AlGaAs Bragg Reflection Waveguides, *Rolf Horn[1], Payam Abolghasem[2], Bhavin Bijlani[2], Amr S. Helmy[2], Gregor Weihs[1]; [1]Dept. of Physics, Univ. of Waterloo, Inst. for Quantum Computing, Canada; [2]The Edward S. Rogers Sr. Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada.* By analyzing the time correlation between two single photon detector events, we demonstrate Spontaneous Parametric Down Conversion of a picosecond pulsed laser in an AlGaAs ridge Bragg Reflection Waveguide.

QThN3 • 15:15

Enhancement of two photon processes in quantum dots embedded in subwavelength metallic gratings, *Moshe G. Harats[1], Ilai Schwarz[1], Ronen Rapaport[1], Adiel Zimran[2], Uri Banin[2], Gang Chen[3]; [1]Racah Inst. fo Physics, The Hebrew Univ. of Jerusalem, Israel; [2]Inst. of Chemistry and The Center for Nanoscience and Nanothechnology, The Hebrew Univ. of Jerusalem, Israel; [3]Bell Laboratories, Alcatel Lucent, USA.* A 20-fold enhancement of two-photon absorption and light upconversion in InAs nanocrystal quantum dots is achieved using resonant local field enhancements in subwavelength nanoslit arrays.

14:30–16:15
QThO • Fundamental Topics in Quantum Science
Dominic Berry, Univ. of Waterloo, Canada, Presider

QThO1 • 14:30

On the Optimal Choice of States for Process Tomography, *Lee A. Rozema[1,2], Ardavan Darabi[1,2], Dylan Mahler[1,2], Robin Blume-Kohout[3,4], Aephraim Steinberg[1,2]; [1]Physics, Univ. of Toronto, Canada; [2]Centre for Quantum Information & Quantum Control and Inst. for Optical Sciences, Canada; [3]Theoretical Division, Los Alamos National Lab, USA; [4]Dept. of Physics and Astronomy, Univ. of New Mexico, USA.* Quantum process tomography requires a set of input states sensitive to the unknown process. We experimentally generate a class of 4-photon states and compare their sensitivity to that of coherent states to a decohering process.

QThO2 • 14:45

Finding Decoherence Free Subspaces Without Process Tomography, *Dylan Mahler[1,2], Lee Rozema[1,2], Aephraim Steinberg[1,2]; [1]Physics, Univ. of Toronto, Canada; [2]Centre for Quantum Information & Quantum Control and Inst. for Optical Sciences, Canada.* Quantum process tomography (QPT) is a resource intensive task. We present an experiment in which a 3 dimensional decoherence free subspace is experimentally identified using 36 measurements, instead of the 256 measurements required for QPT.

QThO3 • 15:00

Experimental Demonstration of Decoherence Suppression by Quantum Measurement Reversal, *Jong-Chan Lee[1], Youn-Chang Jeong[1], Yong-Su Kim[1], Yoon-Ho Kim[1]; [1]Physics, POSTECH, Republic of Korea.* We experimentally demonstrated that the decoherence due to amplitude damping can be suppressed using quantum measurement reversal. By implementing two partial measurements, we succeeded in preferentially selecting the cases without decoherence.

QThO4 • 15:15

Experimental implementation of the universal transpose operation using structural physical approximation, *Hyang-Tag Lim[1], Young-Sik Ra[1], Yong-Su Kim[1], Joonwoo Bae[2], Yoon-Ho Kim[1]; [1]Physics, Pohang Univ. of Science and Technology, Republic of Korea; [2]School of Computational Sciences, Korea Inst. for Advanced Study, Republic of Korea.* We investigate approximating the universal transpose operation of quantum states of two-level systems using the method known as the structural physical approximation to positive maps. We also report its experimental implementation in linear optics.

CLEO: Science & Innovations

14:30–16:15
CThY • Microwave Photonics
Keith Williams, NRL, USA, Presider

CThY1 • 14:30

High-Saturation Current Uni-Traveling-Carrier Waveguide Photodiodes with Variable Optical Confinement, *Jonathan Klamkin[1], Shannon Madison[1], Douglas Oakely[1], Antonio Napoleone[1], Frederick O'Donnell[1], Michael Sheehan[1], Leo Missaggia[1], Janice Caissie[1], Mark Hollis[1], Jason Plant[1], Paul Juodawlkis[1]; [1]Lincoln Lab, Massachusetts Inst. of Technology, USA.* Uni-traveling-carrier photodiodes with variable optical confinement waveguides are proposed and demonstrated. Two different photodiode designs are compared, both demonstrating state of the art saturation current for a waveguide photodiode.

CThY2 • 14:45

Low-Timing-Jitter Near-Infrared Single-Photon-Sensitive 16-Channel Intensified-Photodiode Detector, *Michael Krainak[1], Wei Lu[1], Guangning Yang[1], Xiaoli Sun[1], Derek Sykora[2], Michael Jurkovic[2], Verle Aebi[2], Ken Costello[2], Richard Burns[2]; [1]Laser & Electro-Optic Branch, NASA Goddard Space Flight Center, USA; [2]Intevac, Inc., USA.* We developed a 16-channel InGaAsP photocathode intensified-photodiode (IPD) detector with 78 ps (1-sigma) timing-jitter, < 500 ps FWHM impulse response, >15% quantum efficiency at 1064 nm wavelength with 131 kcps dark counts at 15 C.

CThY3 • 15:00

Noise Reduction by Balanced Detection in Microwave Photonic Filters Based on Optical Broadband Sources, *Xiaoxiao Xue[1], Xiaoping Zheng[1], Hanyi Zhang[1], Bingkun Zhou[1]; [1]State Key Lab on Integrated Optoelectronics, Tsinghua Univ., China.* We propose a microwave photonic filter based on optical broadband source, of which the optical intensity noise is significantly suppressed through polarization-based balanced detection. The signal-to-noise ratio was increased by 15dB experimentally.

CThY4 • 15:15

Combining Multiple Semiconductor Laser Sources for Spectral Pulse Shaping, *David Lemus[1], Mohammad Abtahi[1], Mehrdad Mirshafiei[1], Leslie Rusch[1], Sophie LaRochelle[1]; [1]COPL, Dept. Electrical and Computer Engineering, Université Laval, Canada.* We propose a low cost multiple semiconductor laser source for ultra-wideband pulse generation. The parallel configuration of gain-switched lasers, combined with an adjustable pulse shaper, increases the synthesized waveform resolution.

CLEO: QELS-Fundamental Science

QThK • Tunable and Fluid Metamaterials—Continued

QThK5 • 15:30
Light-induced reflectance changes in a natural photonic structure and measurement of the opto-thermal coefficient of chitin, *Alain Hache[1]; [1]Physics, Universite de Moncton, Canada.* Chitin-based natural photonic structures are studied for light-induced refractive index changes. Strong effects are observed near the photonic band, and the opto-thermal coefficient measured in chitin ($-4.7X10^{-4}/^{o}C^{-1}$) is one of the largest reported.

QThK6 • 15:45
Isotropic Lasing from Self-assembled Cholesteric Microdroplets, *Matjaz Humar[1], Igor Musevic[1,2]; [1]Jozef Stefan Inst., Slovenia; [2]Faculty of Mathematics and Physics, Univ. of Ljubljana, Slovenia.* Here we demonstrate highly tunable single mode lasing from self-assembled microdroplets of cholesteric liquid crystal. This is one of first lasers that emits light isotropically in all directions and thus acts as a point source of light.

QThK7 • 16:00
A Fluid Metamaterial With Tunable Anisotropy, *Mohammad Mayy[1], Guohua Zhu[1], John Kitur[1], Natalia Noginova[1], Carl Bonner[1], Rama Bhattacharjee[2], Emmanuel P. Giannelis[2], Mikhail Noginov[1]; [1]Center for Materials Research, Norfolk State Univ., USA; [2]Materials Science and Engineering, Cornell Univ., USA.* We demonstrate a fluid metamaterial consisting of gold nanorods coated with an organic molecular corona, whose anisotropy can be controlled by applied mechanical shear force.

CLEO: Science & Innovations

CThQ • Nanophotonic Sensors—Continued

CThQ5 • 15:30
Coupled-Resonator Optical Waveguide Sensors Using Multi-Channel Spatial Detection, *Ting Lei[1], Andrew W. Poon[1]; [1]Electronic and Computer Engineering, the Hong Kong Univ. of Science and Technology, Hong Kong.* We demonstrate the proof-of-concept experiments of coupled-resonator optical waveguide sensors using multi-channel out-of-plane light scattering spatial detection. The sensor comprises eleven microdisks, which enables a sensitivity of 10^{-5} RIU.

CThQ6 • 15:45
Interactions of sub-wavelength light scatterers with a Whispering-Gallery-Mode optical microresonator, *Jiangang Zhu[1], Sahin K. Ozdemir[1], Lina He[1], Lan Yang[1]; [1]Electrical & Systems Engineering, Washington Univ. in St. Louis, USA.* Investigation of the dynamics of mode splitting manipulated by two scatterers in an optical microresonator is presented. The phenomena are explained by a multiple-scatterer theory and the applications on nanoparticle sensing are discussed.

CThQ7 • 16:00
High-Q Polymeric Microcavity for Biosensing, *Torsten Beck[1], Mario Hauser[1], Tobias Grossmann[1,2], Dominik Floess[1], Timo Mappes[2], Heinz Kalt[1]; [1]Institut fuer Angewandte Physik, Karlsruhe Inst. of Technology (KIT), Germany; [2]Institut fuer Mikrostrukturtechnik, Karlsruhe Inst. of Technology (KIT), Germany.* We report on a new type of high-Q microresonator made of poly(methyl methacrylate)(PMMA) with a conical shape. First results on biosensing with proteins are presented.

CThR • Novel Applications of Nonlinear Optics—Continued

CThR2 • 15:30 Invited
Large Two-Photon Absorption Enhancement with Extremely Nondegenerate Photons, *Eric Van Stryland[1], Claudiu Cirloganu[2], Dmitry Fishman[1], Scott Webster[1], Lazaro Padilha[3], David J. Hagan[1]; [1]CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA; [2]The School of Electrical and Computer Engineering and Center for Organic Photonics and Electronics, Georgia Inst. of Technology, USA; [3]Los Alamos National Labboratory, USA.* Using extremely nondegenerate photons (energy ratios 10/1), we measure 2-4 orders of magnitude two photon absorption enhancement in semiconductors compared to the degenerate case. We demonstrate subfemtosecond gated detection using a GaN photodiode.

CThR3 • 16:00
Optical Domain Wideband RF Spectrum Analysis Using Parametric Mixing, *Joshua Kvavle[1], James Adleman[1], Christopher Huynh[1], Camille Bres[2], Sanja Zlatanovic[2], Andreas Wiberg[2], Bill Kuo[2], Evgeny Myslivets[2], Stojan Radic[2], Everett Jacobs[1]; [1]SSC Pacific, USA; [2]Electrical and Computer Engineering, Univ. of California San Diego, USA.* We present the design of an optical domain staring RF spectrum analyzer based on parametric multicasting and spectral slicing with a periodic filter. An implementation covering an 18GHz band with 250MHz resolution bandwidth is presented.

CThS • CLEO Symposium on Broadband Spectroscopy: New Techniques and Sources II: Spectroscopic Experiments—Continued

CThS3 • 15:30 Invited
Molecular sensing with supercontinuum radiation, *Clemens Kaminski[1,2], Ssegawa Kiwanuka[1], Toni Laurila[1]; [1]Chemical Engineering and Biotechnology, Univ. of Cambridge, UK; [2]SAOT School of Advanced and Optical Technologies, Univ. of Erlangen-Nuremberg, Germany.* Novel applications in gas and liquid phase molecular sensing are presented, which make use of the unique properties of supercontinuum radiation. Challenges and future opportunities are discussed.

CThS4 • 16:00
Hyperspectral Infrared Microscopy of Explosives Particles Using an External Cavity Quantum Cascade Laser, *Mark C. Phillips[1], Bruce E. Bernacki[1]; [1]Pacific Northwest National Lab, USA.* A hyperspectral infrared microscope using external cavity quantum cascade laser illumination and a microbolometer focal plane array is used to characterize nanogram-scale particles of the explosives RDX, tetryl, and PETN at fast acquisition rates.

16:15–16:45 Coffee Break, *300 Level Lobby*

CLEO: Science & Innovations

CThT • Gas Phase Sensing I—Continued

CThT4 • 15:30
Chirped Laser Dispersion Spectroscopy with baseline-free 2nd harmonic detection, *Michal Nikodem[1], Clinton J. Smith[1], Damien Weidmann[2], Gerard Wysocki[1]; [1]Electrical Engineering, Princeton Univ., USA; [2]STFC Rutherford Appleton Lab, UK.* A phase sensitive signal detection scheme for molecular spectroscopy based on chirped laser dispersion spectroscopy (CLaDS) is presented. We demonstrate application to sensitive remote sensing of trace gases using a 5.2 μm quantum cascade laser.

CThT5 • 15:45
LED-based CO_2 Sensor for Balloon Deployment, *David Sonnenfroh[1], Krishnan Parameswaran[1]; [1]Physical Sciences Inc., USA.* We are developing a sensor for monitoring ambient CO_2 from unmanned aircraft and balloons. The sensor consists of a mid-IR LED coupled with a high dynamic range gated integrator. The measurement precision is 0.4 ppmv at 30 seconds.

CThT6 • 16:00
Monitoring of atmospheric ammonia in the greater Houston area using a 10.4 μm external-cavity quantum cascade laser, *Rafal Lewicki[1], Longwen Gong[2], Robert Griffin[2], Timothy Day[3], Frank K. Tittel[1]; [1]Electrical and Computer Engineering, Rice Univ., USA; [2]Civil and Environmental Engineering, Rice Univ., USA; [3]Daylight Solutions Inc., USA.* Amplitude modulated photo-acoustic spectroscopy using a 10.4 μm EC-QCL source, targeting the NH_3 absorption line at 965.35 cm^{-1}, resulted in a sub-ppb ammonia detection limit. Atmospheric ammonia concentration levels from our study will be reported.

CThU • Fiber Amplifiers and Lasers—Continued

CThU5 • 15:30
Influence of modulation of pump and seed signals on fiber amplification of broadband pulses, *Kutan Gurel[1], Parviz Elahi[1], Cagri Senel[1], Punya Paltani[1], Fatih Omer Ilday[1]; [1]Physics Dept., Bilkent Univ., Turkey.* We report on characterization of the transfer of pump and seed signal modulations, including noise, during fiber amplification. We demonstrate experimentally and theoretically that pump (signal) modulations are transferred only below (above) a cut-off frequency.

CThU6 • 15:45
Single-Frequency Photonic Bandgap Fiber Amplification, *Akira Shirakawa[1], Meishin Chen[1], Yoshiaki Yamahara[1], Ken-ichi Ueda[1], Christina B. Olausson[2], Jens K. Lyngsø[2], Jes Broeng[2]; [1]Inst. for Laser Science, Univ. of Electro-Communications, Japan; [2]NKT Photonics A/S, Denmark.* Single-frequency operation in an ytterbium-doped photonic bandgap fiber amplifier is presented for the first time. 16W, 1178nm narrow linewidth radiation, free from amplified spontaneous emission and stimulated Brillouin scattering, was obtained.

CThU7 • 16:00
High power tandem pumped photonic crystal fiber amplifier, *Christian Wirth[1], Oliver Schmidt[1], Thomas Schreiber[1], Ramona Eberhardt[1], Andreas Tünnermann[1]; [1]Fraunhofer IOF Jena, Germany.* We report on a photonic crystal fiber amplifier tandem pumped by an industrial style thin-disk laser. Brightness enhancement with an output power of 1 kW and a slope of 74% has been obtained.

CThV • THz Imaging—Continued

CThV5 • 15:30
High-sensitivity *in vivo* THz fiber-scanning mammography of early breast cancer in nude mice, *Hua Chen[1], Tzu-Fang Tseng[1], Jen-Tang Lu[1], Chen Te-Hsuen[2], Chung-Chiu Kuo[1], Shih-Chen Fu[3], Wen-Jeng Lee[1], Yuan-Fu Tsai[1], Yu-You Huang[2], Eric Y. Chuang[3], Yuh-Jing Hwang[5], Chi-Kuang Sun[1,4]; [1]Graduate Inst. of Photonics and Optoelectronics, National Taiwan Univ., Taiwan; [2]Graduate Inst. of Biomedical Engineering, National Taiwan Univ., Taiwan; [3]Graduate Inst. of Biomedical Electronics and Bioinformations, National Taiwan Univ., Taiwan; [4]Inst. of Physics and Research Center for Applied Sciences, Academia Sinica, Taiwan; [5]Inst. of Astronomy and Astrophysics Sinica, Academia Sinica, Taiwan.* We demonstrate an in vivo T-ray mammography for early breast cancer detection in an animal model. Compared to the sensitivity of X-ray mammography(Volume: 4.22mm^3),T-ray achieved much earlier cancer detection(Volume: 0.5mm^3).

CThV6 • 15:45
Real-Time Line Projection for Fast Terahertz Computed Tomography, *Emmanuel Abraham[1], Yoshiyuki Oghi[2], Tsutomu Araki[2], Takeshi Yasui[2,3]; [1]Centre de Physique Moléculaire Optique et Hertzienne, Bordeaux Univ., France; [2]Graduate School of Engineering Science, Osaka Univ., Japan; [3]Inst. of Technology and Science, Univ. of Tokushima, Japan.* We demonstrated fast terahertz computed tomography by use of real-time line projection of a terahertz beam. Cross-sectional images of selected samples have been measured in only a few seconds.

CThV7 • 16:00
Single-pixel coherent diffraction imaging with THz waves, *Kang Hee Lee[1], Jaewook Ahn[1]; [1]Physics, KAIST, Republic of Korea.* We propose and demonstrate single-pixel coherent diffraction imaging with ultrafast THz waves, whereby all the spatial frequency components processed by a spatial phase retarder are simultaneously measured by a fixed-location single-pixel detector.

16:15–16:45 Coffee Break, *300 Level Lobby*

CLEO: QELS Fundamental Science

QThL • Positioning, Coupling and Focusing in Nanophotonic Systems—Continued

QThL5 • 15:30
Nanofocusing in Nonlinear Plasmonic Tapered Waveguides, *Artur Davoyan[1], Ilya V. Shadrivov[1], Alexander Zharov[2], Dmitri Gramotnev[3], Yuri S. Kivshar[1]; [1]Nonlinear Physics Centre, Australian National Univ., Australia; [2]Inst. for Physics of Microstructures, Russian Federation; [3]Nanophotonics, GPO Box 786, Australia.* We study propagation of surface plasmon polaritons in a nonlinear tapered slot waveguide and demonstrate taper-induced plasmon nanofocusing and the formation of a plasmon soliton.

QThL6 • 15:45
Slow-light enhanced absorption switches in metal-dielectric-metal plasmonic waveguides, *Changjun Min[1], Georgios Veronis[1]; [1]Louisiana State Univ., USA.* We introduce slow-light enhanced absorption switches in subwavelength metal-dielectric-metal plasmonic waveguides. Both decent modulation depth and moderate insertion loss can be achieved in such switches by small induced changes in refractive index.

QThL7 • 16:00
Deterministic Nano-manipulation of Single Photon Sources for Integration, *Chad Ropp[1], Roland Probst[2], Zachary Cummins[3], Rakesh Kumar[4], Sijia Qin[5], John T. Fourkas[5], Srinivasa R. Raghavan,[4], Benjamin Shapiro[3], Edo Waks[1]; [1]Dept. of Electrical and Computer Engineering, Univ. of Maryland, USA; [2]Dept. of Aerospace Engineering, Univ. of Maryland, USA; [3]Fischell Dept. of Bio-Engineering, Univ. of Maryland, USA; [4]Dept. of Chemical and Biomolecular Engineering, Univ. of Maryland, USA; [5]Dept. of Chemistry and Biochemistry, Univ. of Maryland, USA.* Preselected single photon sources are positioned and immobilized to nanometer precision using flow control and local polymerization. This technique can be useful for integration of single photon sources within nanophotonic structures.

CLEO: Science & Innovations

CThW • Advances in Biological Microscopy—Continued

CThW5 • 15:45
Efficient schemes for adaptive optics in high-resolution microscopy, *Anisha Thayil[1], Alexander Jesacher[1], Martin Booth[1]; [1]Dept of Engineering Science, Univ. of Oxford, UK.* Aberrations affect image quality in high-resolution microscopes. We develop efficient adaptive optics schemes to correct aberrations in confocal and multiphoton microscopes. Image resolution and contrast is improved with minimal specimen exposure.

CThW6 • 16:00
Contrast Enhancement by Multi-Pass Phase-Conjugation Microscopy, *Nicolas C. Pégard[1], Jason W. Fleischer[1]; [1]Electrical Engineering, Princeton Univ., USA.* We demonstrate a non-invasive bright field imaging technique that optically enhances contrast for any weakly absorbing object. Results are shown on microscopic biomaterial. All-optical image processing and other filtering capabilities are discussed.

CLEO: QELS Fundamental Science

QThM • Quantum Optics in Cavities and Waveguides—Continued

QThM5 • 15:30
Ultra-High Finesse, Low Mode Volume Fabry-Perot Microcavity, *Andreas Muller[1,3], Edward B. Flagg[1], John Lawall[2], Glenn Solomon[1,2], David Gershoni[1,4]; [1]Joint Quantum Inst., National Inst. of Standards and Technology and Univ. of Maryland, USA; [2]Atomic Physics Division, National Inst. of Standards and Technology, USA; [3]Univ. of South Florida, USA; [4]Physics Dept., Technion, Israel.* We construct microcavities comprising ultralow-loss micromirrors fabricated by laser ablation and reflective coatings. With quality factors of 3.3e6 and finesses of 1.5e5, strong coupling or lasing with a single quantum emitter may be achieved.

QThM6 • 15:45
Observation of strong coupling through transmission modification of a cavity-coupled photonic crystal waveguide, *Ranojoy Bose[1,2], Deepak Sridharan[1,2], Edo Waks[1,2], Glenn Solomon[2]; [1]Electrical Engineering, Univ. of Maryland, USA; [2]Joint Quantum Inst., Univ. of Maryland, USA.* We observe strong coupling in a waveguide-coupled photonic crystal-quantum dot system through a modification in the transmission spectrum of resonant light through the waveguide.

QThM7 • 16:00
Photon correlations in multi-cavity nonlinear systems, *Dario Gerace[1], Hakan E. Tureci[2], Sara Ferretti[1], Lucio C. Andreani[1], Atac Imamoglu[3], Vittorio Giovannetti[4], Rosario Fazio[4]; [1]Dept. of Physics "A. Volta", Univ. of Pavia, Italy; [2]Electrical Engineering, Princeton Univ., USA; [3]Inst. of Quantum Electronics, ETH Zurich, Switzerland; [4]Scuola Normale Superiore, Italy.* Second-order photon correlation measurements are established not only as a probe of single-photon nonlinear behaviour of a single cavity, but as an effective probe of the out-of-equilibrium manybody state in multiple tunnel-coupled nonlinear cavities.

CLEO: Science & Innovations

CThX • Fiber Transmission—Continued

CThX5 • 15:30 Invited
Demonstration of 10-40-Gbaud Baud-Rate-Tunable Optical Generation of 16-QAM from a QPSK Signal Using a Variable DGD Element, *Zahra Bakhtiari[1], Jian Wang[1], Xiaoxia Wu[1], Jeng-Yuan Yang[1], Scott R. Nuccio, Robert Hellwarth[1], Alan E. Willner[1]; [1]Univ. of Southern California, USA.* We experimentally demonstrate a tunable optical generation of up to 40-Gbaud 16-QAM from a QPSK signal using a variable DGD element based on vector addition between two orthogonal polarization states of the input QPSK signal.

CThX6 • 16:00
Radiation-driven phase drift in stochastic nonlinear Schrödinger equations, *Daniel Cargill[2], Richard O. Moore[2], Colin J. McKinstrie[1]; [1]Bell Laboratories, Alcatel-Lucent, USA; [2]Mathematical Sciences, NJIT, USA.* Soliton perturbation theory predicts an incorrect phase distribution for solitons of stochastically-driven nonlinear Schrödinger equations. We propose a simple variational model that accounts for radiation and produces the correct phase evolution.

16:15–16:45 Coffee Break, *300 Level Lobby*

NOTES

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

QThN • Quantum Photonics—Continued

QThN4 • 15:30
Generation and Verification of Traveling-wave Phase-sensitive Eigenmodes of an Optical Parametric Amplifier, *Amar Bhagwat[1], Gideon Alon[1], Oo-Kaw Lim[1], Chao-Hsiang Chen[1], Prem Kumar[1], Muthiah Annamalai[2], Michael Vasilyev[2]; [1]EECS Dept., Northwestern Univ., USA; [2]Dept.of Electrical Engineering, Univ. of Texas at Arlington, USA.* We investigate the eigenmodes of a traveling-wave phase-sensitive optical parametric amplifier. We observe gain (deamplification) of 11.4 dB (-7.9 dB) for a Laguerre-Gaussian LG_{00} mode with >95% overlap with the fundamental eigenmode.

QThN5 • 15:45
Improvement of Image Resolution beyond Classical Limit by Phase-sensitive Optical Parametric Amplifier, *Zun Huang[1], Douglas C. French[2], Igor Jovanovic[2], Hsueh-Yuan Pao[3]; [1]ECE, Purdue Univ., USA; [2]Mechanical and Nuclear Engineering, Pennsylvania State Univ., USA; [3]Lawrence Livermore National Lab, USA.* When an optical parametric amplifier (OPA) operated as a phase-sensitive amplifier (PSA) is used for point source imaging, the angular resolution improvement can defeat the classical Rayleigh limit, and approach the de Broglie resolution.

QThN6 • 16:00
Single-Photon Tunneling Delay in a Nematic Liquid-Crystal Frustrated-Total-Internal-Reflection Structure, *George M. Gehring[1], Andreas C. Liapis[1], Svetlana G. Lukishova[2], Robert W. Boyd[1,3]; [1]Optics, Univ. of Rochester, USA; [2]Lab for Laser Energetics, Univ. of Rochester, USA; [3]Physics, Univ. of Ottawa, Canada.* We present a new theoretical treatment of photon tunneling delay in frustrated total internal reflection based on a dwell-time interpretation of the Hartman effect, as well as preliminary experimental measurements of single-photon delay.

QThO • Fundamental Topics in Quantum Science—Continued

QThO5 • 15:30 Invited
Quasiprobability representations of quantumness, *Werner Vogel[1], Thomas Kiesel[1], Jan Sperling[1]; [1]Physik, Universitaet Rostock, Germany.* Quasiprobability representations of quantumness are developed, which include entanglement and space-time dependent field correlations. General quantum effects are visualized by negativities of regular functions being accessible in experiments.

QThO6 • 16:00
Extracting an entanglement signature from only classical mutual information, *David J. Starling[1], John C. Howell[1]; [1]Univ. of Rochester, USA.* We use classical mutual information to characterize two photons measured in three mutually unbiased bases. We theoretically and experimentally compare entangled and separable states and find a bound on the information capacity of the pair.

CThY • Microwave Photonics—Continued

CThY5 • 15:30
Analysis of Spur-Free Dynamic Range of a Semiconductor Resonant Cavity Linear Interferometric Intensity Modulator, *Nazanin Hoghooghi[1], Peter J. Delfyett[1]; [1]CREOL, College of Optics and Photonics, Univ. of Centeral Florida, USA.* Numerical simulation of spur-free dynamic range (SFDR) of an injection locked semiconductor resonant cavity interferometric intensity modulator is presented. Theoretically calculated values are in good agreement with experimental results.

CThY6 • 15:45
10GHz Waveguide Interleaved Femtosecond Pulse Train, *Michelle Y. Sander[1], Hyunil Byun[1], Marcus Dahlem[1], David Chao[1], Ali R. Motamedi[1], Gale Petrich[1], Leslie Kolodziejski[1], Sergev Frolov[2], Hong Hao[2], Joseph Shmulovich[2], Erich P. Ippen[1], Franz X. Kaertner[1]; [1]Massachusetts Inst. of Technology, USA; [2]CyOptics, Inc., USA.* We demonstrate a 10GHz fs-pulse train by external repetition rate multiplication in four phase-tunable Mach-Zehnder interleavers implemented in planar waveguide technology. A minimum RF suppression ratio of -27dB can be achieved with thermal tuning.

CThY7 • 16:00
Integrated optical phase locked loop, *Amir H. Nejadmalayeri[1], Hyunil Byun[1], Jungwon Kim[1], Douglas C. Trotter[2], Christopher DeRose[2], Anthony L. Lentine[2], William A. Zortman[2], Michael R. Watts[1,2], Franz X. Kaertner[1]; [1]RLE, MIT, USA; [2]Sandia National Laboratories, USA.* A silicon photonics based integrated optical phase locked loop is utilized to synchronize a 10.2 GHz voltage controlled oscillator with a 509 MHz mode locked laser, achieving 32 fs integrated jitter over 300 kHz bandwidth.

16:15–16:45 Coffee Break, *300 Level Lobby*

NOTES

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

16:45–18:15
QThP • Hyperbolic and Anistropic Metamaterial
Mikhail Noginov, Norfolk State Univ., USA, Presider

QThP1 • 16:45
Optical Devices Based on Cylindrically Anisotropic Metamaterials, *Huikan Liu[1], Kevin J. Webb[1]; [1]Purdue Univ., USA.* By exploiting resonance cones inside cylindrically anisotropic materials, we present two optical devices, a multiplexer based on the dispersive properties of a metal-insulator stack metamaterial, and a far-field bilayer subwavelength imaging system.

QThP2 • 17:00
Transverse electro-magnetic modes in apertures filled with an extreme anisotropic meta-material, *Peter B. Catrysse[1], Shanhui Fan[1]; [1]Edward L. Ginzton Lab, Stanford Univ., USA.* We demonstrate that in simply connected apertures containing a meta-material with extreme anisotropy all modes become purely transverse electro-magnetic, dispersion-free, and have no cutoff. We show a meta-material design using existing materials.

QThP3 • 17:15
Broadband Engineering of Quantum Dot Spontaneous Emission Using Flat Dispersion Metamaterial, *Harish Krishnamoorthy[1,2], Vinod Menon[1,2], Zubin Jacob[3], Evgenii Narimanov[4], Ilona Kretzschmar[5]; [1]Dept. of Physics, Queens College of the City Univ. of New York (CUNY), USA; [2]Dept. of Physics, Graduate School and Univ. Center of the City Univ. of New York (CUNY), USA; [3]Dept. of Electrical and Computer Engineering, Univ. of Alberta, Canada; [4]School of Electrical and Computer Engineering, Purdue Univ., USA; [5]Dept. of Chemical Engineering, City College of the City Univ. of New York (CUNY), USA.* We report the broadband (~ 25 nm) control of radiative decay rate of colloidal quantum dots by exploiting the flat dispersion of a one-dimensional nonmagnetic metamaterial structure.

QThP4 • 17:30
Dipole Radiation Near Hyperbolic Metamaterials: Applicability of Effective Medium Approximation, *Omar Kidwai[1], Sergei V. Zhukovsky[1], J. E. Sipe[1]; [1]Dept. of Physics, Univ. of Toronto, Canada.* Radiation rate of a dipole in close proximity to a hyperbolic metamaterial is theoretically investigated. Homogenized effective medium is found to overestimate the Purcell factor compared to real metal-dielectric subwavelength multilayers.

16:45–18:30
CThZ • Novel Waveguides and Resonators
Carl Poitras, Cornell Univ., USA, Presider

CThZ1 • 16:45
Smooth and ultra-precise silicon nanowires fabricated by conventional optical lithography, *Robert Palmer[1], Luca Alloatti[1], Dietmar Korn[1], Markus Moosmann[2,3], Klaus Huska[4], Uli Lemmer[4], Dagmar Gerthsen[5], Thomas Schimmel[2,3], Wolfgang Freude[1], Christian Koos[1], Juerg Leuthold[1]; [1]Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; [2]Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany; [3]Applied Physics, Karlsruhe Inst. of Technology, Germany; [4]Light Technology Inst., Karlsruhe Inst. of Technology, Germany; [5]Lab for Electron Microscopy, Karlsruhe Inst. of Technology, Germany.* We demonstrate that nanowire waveguides with nanoscale precision and ultra-smooth sidewalls can be fabricated with conventional optical lithography. The presented fabrication scheme exploits the combination of a special staggered lithographic design and preferential wet etching.

CThZ2 • 17:00
Nanoscale oxidation of silicon microring resonators, *Yiran Shen[1], Shayan Mookherjea[1]; [1]Electrical ad Computer Engineering, Univ. of California San Diego, USA.* The resonance frequency of a silicon microring was permanently blue-shifted with 1.2 GHz resolution over more than 350 GHz, a full free-spectral-range, by electrochemically changing the waveguide core (silicon) to the cladding (oxide) material.

CThZ3 • 17:15
Vertical Chip-to-Chip Coupling Using Silicon Strip Waveguide Cantilever Couplers, *Peng Sun[1], Ronald M. Reano[1]; [1]Electrical and Computer Engineering, Ohio State Univ., USA.* We demonstrate vertical chip-to-chip light coupling using silicon strip waveguide cantilever couplers. A chip-to-chip coupling loss of 2.5 dB per connection is measured for TE polarization at 1550 nm wavelength.

CThZ4 • 17:30
Hollow-Core-Waveguides using Adiabatically Chirped High-Contrast-Gratings for a >10× Loss Reduction, *Yang Yue[1], Lin Zhang[1], Xue Wang[1], Hao Huang[1], Weijian Yang[2], James Ferrara[2], Vadim Karagodsky[2], Christopher Chase[2], Moshe Tur[3], Connie J. Chang-Hasnain[2], Alan E. Willner[1]; [1]1. Dept. of Electrical Engineering, Univ. of Southern California, USA; [2]Dept. of Electrical Engineering and Computer Sciences, Univ. of California, Berkeley, USA; [3]School of Electrical Engineering, Tel-Aviv Univ., Israel.* Chirped high-contrast-grating hollow-core waveguide demonstrates a >10× loss reduction. Simulation shows that a propagation loss as low as 0.04 dB/cm can be achieved with a nonlinear coefficient on the order of 10^{-5} /W/m.

16:45–18:30
CThAA • Mode-Locked Solid State Lasers
Henry Kapteyn, Dept. of Physics and JILA, Univ. of Colorado, USA, Presider

CThAA1 • 16:45 Invited
Carbon Nanotube Saturable Absorbers for Bulk Solid-State Laser Mode-Locking, *Fabian Rotermund[1]; [1]Division of Energy Systems Research, Ajou Univ., Republic of Korea.* Single-walled carbon nanotube-based saturable absorbers have been successfully applied for passive mode-locking bulk solid-state lasers operating in the spectral range between 800 nm and 2 µm. In this talk, the recent progress will be presented.

CThAA2 • 17:15
Femtosecond Pulses Generation from Chromium-doped Cunyite Laser, *Michelet Jeanty[2], Vladimir Kartazaev[1], Mikhail Sharonov[1], Alexei Bykov[1], Robert Alfano[1,2]; [1]Physics Dept., City College of New York, USA; [2]Electrical Engineering, City College of New York, USA.* Femtosecond pulses as short as 365 fs were generated from a Cr^{4+}: Cunyite laser using a combination of a broadband semiconductor saturable absorber mirror (SESAM), chirped mirrors, and passive mode locking.

CThAA3 • 17:30
Picosecond Tunable Mode-Locking of a Cr^{2+}:ZnSe Laser with a Frequency-Doubling Nonlinear Mirror, *Jean-Baptiste Dherbecourt[1], Adrien Denoeud[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Antoine Godard[1], Michel Lefebvre[1], Emmanuel Rosencher[1]; [1]ONERA - the French Aerospace Lab, France.* We report on a nonlinear mirror based on a fan-out PPLN crystal that enables tunable mode-locking of a Cr^{2+}:ZnSe laser in the picosecond regime. More than 100 nm tunability is demonstrated.

16:45–18:15
CThBB • CLEO Symposium on Broadband Spectroscopy: New Techniques and Sources III: Sources
Ian Coddington, NIST, USA, Presider

CThBB1 • 16:45 Invited
Frequency Divide-and-Conquer Approach to Producing Ultra-broadband Mid-IR Combs, *Konstantin Vodopyanov[1]; [1]Stanford Univ., USA.* We introduce a new approach for producing mid-IR frequency combs using degenerate sync-pumped optical parametric oscillation. Octave-wide frequency combs centered at 3.1µm, frequency- and phase-locked to the pump fiber laser, were demonstrated.

CThBB2 • 17:15
ZBLAN supercontinuum generation - detailed comparison between measurement and simulation, *Christian Agger[1], Christian Petersen[3], Sune Dupont[3], Henrik Steffensen[1], Jens Kristian Lyngsø[2], Carsten Thomsen[2], Søren Keiding[3], Ole Bang[1]; [1]DTU Fotonik, Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark; [2]NKT Photonics, Denmark; [3]Dept. of Chemistry, Aarhus Univ., Denmark.* We present a detailed comparison between modeling and experiments on supercontinuum generation in a ZBLAN fiber. Good agreement is obtained when pumping both in the normal and anomalous dispersion regimes.

CThBB3 • 17:30
3-octave high-energy supercontinuum from visible to mid-IR, *Francisco Silva[1], Dane R. Austin[1], Arnaud Couairon[2], Philip K. Bates[1], Jens Biegert[1,3]; [1]ICFO-Institut de Ciencies Fotoniques, Spain; [2]Centre de Physique Theorique, Ecole Polytechnique, CNRS UMR, France; [3]ICREA-Institució Catalana de Recerca i Estudis Avançats, Spain.* We demonstrate a 3-octave supercontinuum with spectral density ranging from 10 pJ/nm to 25 nJ/nm over 500 nm to above 4.5 µm, generated through filamentation in bulk by CEP-stable 30 fs pulses centered at 2.1 µm.

CLEO: Science & Innovations

16:45–18:30
CThCC • Gas Phase Sensing II
Sukesh Roy, Spectral Energies, LLC, USA, Presider

CThCC1 • 16:45 Invited

Laser Induced Fluorescence for Quantitative Temperature and Concentration Measurements in Internal Combustion Engines, *Frank Beyrau[1]; [1]Mechanical Engineering, Imperial College London, UK.* Laser induced fluorescence is used to acquire quantitative temperature and concentration images from optical engines. The quantification strategy using two wavelengths excitation, calibration results and exemplary results are presented.

CThCC2 • 17:15

CH Fluorescence Imaging at High Repetition Rates, *Joseph D. Miller[1], Sascha R. Engel[2,3], Terrence R. Meyer[1,3], Thomas Seeger[3,4], Alfred Leipertz[2,3]; [1]Mechanical Engineering, Iowa State Univ., USA; [2]Engineering Thermodynamics, Univ. of Erlangen-Nuremberg, Germany; [3]SAOT - Erlangen Graduate School in Advanced Optical Technologies, Univ. of Erlangen-Nuremberg, Germany; [4]Engineering Thermodynamics, Univ. of Siegen, Germany.* We introduce a novel strategy to acquire CH PLIF images at high repetition rates. A multi-mode pumped optical parametric oscillator (OPO) which produces signal at 431 nm is used for direct excitation of the CH radical.

CThCC3 • 17:30

Local Composition and Temperature Determination in Laminar Flames by Laser-Induced Plasma Diagnostics, *Johannes Kiefer[1,2], Johannes W. Troeger[3,2], Thomas Seeger[3,2], Alfred Leipertz[2], Zhongshan Li[4], Marcus Alden[4]; [1]School of Engineering, Univ. of Aberdeen, UK; [2]Inst. of Engineering Thermodynamics and Erlangen Graduate School in Advanced Optical Technologies, Univ. Erlangen-Nuremberg, Germany; [3]Inst. of Engineering Thermodynamics, Univ. Siegen, Germany; [4]Division of Combustion Physics, Lund Univ., Sweden.* We utilize laser-induced breakdown spectroscopy for measuring mixture composition and temperature in flames. Spectroscopy of the plasma emission yields concentration information, while temperature is derived from the breakdown threshold pulse energy.

16:45–18:30
CThDD • Pulsed Fiber Lasers
John Minelly, Coherent, Inc., USA, Presider

CThDD1 • 16:45

Coherent Ultrashort Pulse Generation from Incoherent Light by Trapped Pulse Amplification in Birefringent Fibers, *Eiji Shiraki[1], Norihiko Nishizawa[1]; [1]Electrical Engineering and Computer Science, Nagoya Univ., Japan.* 48 pJ, 413 fs, chirp-free, sech^2-shaped, coherent, ultrashort pulse was generated from an incoherent light of super luminescent diode using pulse trapping and amplification by an ultrashort soliton pulse in a 400 m-long birefringent fiber.

CThDD2 • 17:00

High-energy temporally-shaped nanosecond-pulse MOPA based on Ytterbium-doped single-mode microstructured flexible fiber, *Laure Lago[1,2], Damien Bigourd[1], Arnaud Mussot[2], Marc Douay[2], Emmanuel Hugonnot[1]; [1]CEA, France; [2]Université des Sciences et Technologies de Lille - PhLAM/IRCICA, France.* We present a versatile MOPA system at 1053nm in the few nanoseconds regime. Thanks to temporal shaping, more than 1.5 mJ pulse energy at 1 kHz is obtained in a single-mode 40 µm core flexible fiber.

CThDD3 • 17:15

Tunable nanosecond ytterbium-doped master-oscillator fiber amplifier system, *Romain Royon[1], Jerome Lhermite[1], Guillaume Machinet[1], Laurent Sarger[2], Eric Cormier[1]; [1]Laboratoire CELIA, France; [2]CPMOH, France.* We report a sub-nanosecond fiber laser tunable between 1040-1100 nm and delivering 5 W average output power corresponding to 0,25 mJ energy per pulse and peak power of 280 kW.

CThDD4 • 17:30

A Tunable Fiber Laser For The 2µm Wavelength Range Based on Narrow Band Optical Parametric Amplification And An Intra-Cavity Thulium Doped Fiber Active Filter, *Alexander Gershikov[1], Jakov Lasri[2], Sacks Zachary[3], Gadi Eisenstein[1]; [1]Electrical Engineering, The Technion - Israel Inst. of Technology, Israel; [2]OptiSiv Ltd, Israel; [3]Elbit Systems, Israel.* We describe a tunable fiber laser operating at 2µm and beyond based on narrow band parametric amplification and a Tm doped intracavity fiber filter. Nanosecond pulses at ~1MHz with a 20W peak power are demonstrated.

16:45–18:30
CThEE • THz Spectroscopy
Daniel Grischkowsky, Oklahoma State Univ., USA, Presider

CThEE1 • 16:45

High Resolution THz-TDS using Flare Coupled Metal Parallel-Plate Waveguides, *Michael Theuer[1], S. Sree Harsha[2], Alisha J. Shutler[2], Rene Beigang[1], Daniel R. Grischkowsky[2]; [1]Dept. of Physics, Univ. of Kaiserslautern, Germany; [2]Dept. of Electrical Engineering, Oklahoma State Univ., USA.* We report on the microwave approach of coupling terahertz radiation into metal parallel-plate waveguides. The coupling ratio is compared to the quasi-optic coupling using Si lenses. High resolution THz spectroscopy of crystalline films is presented

CThEE2 • 17:00

Nonlinear Optical Response of Graphene to an Ultrashort Intense Terahertz Pulse, *Kenichi L. Ishikawa[1]; [1]Photon Science Center, Graduate School of Engineering, The Univ. of Tokyo, Japan.* The optical response of graphene to an ultrashort intense terahertz pulse is described by the extended optical Bloch equations. The interplay of intraband and interband dynamics is important in the nonlinear optical response.

CThEE3 • 17:15

Terahertz Spectroscopy of Ni-Ti Alloy Thin Films, *Andrew D. Jameson[1], Joseph L. Tomaino[1], Joshua Kevek[1], Meghan Hemphill-Johnston[2], Justin Ong[2], Milo D. Koretsky[2], Ethan D. Minot[1], Yun-Shik Lee[1]; [1]Physics, Oregon State Univ., USA; [2]School of Chemical, Biological & Environmental Engineering, Oregon State Univ., USA.* Using THz spectroscopy, we obtained the resistivity of Ni-Ti alloy thin-films as a function of Ti concentration. The resistivity sharply increases near the phase transition boundaries, Ti concentrations of 22%, 44% and 62%.

CThEE4 • 17:30

Terahertz Imaging and Spectroscopy of Large-Area Single-Layer Graphene, *Joseph L. Tomaino[1], Andrew D. Jameson[1], Joshua Kevek[1], Michael J. Paul[1], Arend M. van der Zande[2], Robert A. Barton[3], Ethan D. Minot[1], Paul L. McEuen[2,4], Yun-Shik Lee[1]; [1]Physics, Oregon State Univ., USA; [2]Lab of Atomic and Solid-State Physics, Cornell Univ., USA; [3]School of Applied and Engineering Physics, Cornell Univ., USA; [4]Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA.* THz imaging and spectroscopy using broadband THz pulses map out the THz carrier dynamics of a large-area graphene-on-Si sample, showing that the local sheet-conductivity varies across the sample from $\sigma_s = 1.7\text{x}10^{-3}$ to $2.4\text{x}10^{-3}\ \Omega^{-1}$.

Room 327

CLEO: QELS-Fundamental Science

16:45–18:30
QThQ • Plasmon Optics
Harry Atwater, Caltech, USA, Presider

QThQ1 • 16:45 Invited
Off-axis and multi-directional plasmonic lenses, *Romain Blanchard[1], Jean-Philippe Tetienne[1], Nanfang Yu[1], Patrice Genevet[1], Mikhail A. Kats[1], Jonathan Fan[1], Tadataka Edamura[2], Shinichi Furuta[2], Masamichi Yamanishi[2], Federico Capasso[1]; [1]School of Engineering and Applied Sciences, Harvard Univ., USA; [2]Research Lab, Hamamatsu Photonics K. K., Japan.* We introduce a new class of plasmonic lenses generating one or several free-space beams in arbitrary directions from a point source of surface waves and demonstrate such plasmonic lenses on the facet of semiconductor lasers.

QThQ2 • 17:15
Gold Nanoslit Lenses, *Satoshi Ishii[1], Alexander Kildishev[1], Vladimir Shalaev[1], Kuo-Ping Chen[1], Vladimir P. Drachev[1]; [1]Purdue Univ., USA.* We experimentally demonstrate the focusing properties of arrays of parallel subwavelength-wide nanoslits in a gold film. The lenses are designed to focus either TM- or TEpolarized light and diverge the light of the orthogonal polarization.

QThQ3 • 17:30
Tailoring Polarization State of Spoof Surface Plasmons with Chiral Metal Surfaces, *Alexander B. Khanikaev[1], Hossein Mousavi[1], Burton Neuner III[1], Gennady Shvets[1]; [1]Physics, The Univ. of Texas at Austin, USA.* Spoof surface modes with engineered polarization state are predicted to exist at the structured conducting surfaces with planar chirality. We confirm experimentally that excitation of these modes by incident light results in polarization rotation.

Room 336

CLEO: Science & Innovations

16:45–18:30
CThFF • Filamentation
Gary Catella, Gooch and Housego, USA, Presider

CThFF1 • 16:45
Triggering, guiding and deviation of long spark discharges with femtosecond laser filament, *Benjamin Forestier[1], Aurélien Houard[1], Magali Durand[1], Yves-Bernard Andre[1], Bernard Prade[1], André Mysyrowicz[1], Marc Le Nevé[2], Jean-Claude De Miscault[2], Ivan Revel[3], Denis Chapuis[3]; [1]LOA, ENSTA ParisTech, Ecole Polytechnique, CNRS, France; [2]CILAS, France; [3]EADS France Innovation Works, France.* We show for the first time that filaments are able to divert electric discharges from their normal path. Comparison between negative and positive discharge polarities reveals important differences in the guiding mechanism.

CThFF2 • 17:00
Characterization of laser-induced air plasmas via third harmonic generation, *Cristina Rodriguez[1], Zhenwei Wang[1], Zhanliang Sun[1], Wolfgang Rudolph[1]; [1]Physics and Astronomy, Univ. of New Mexico, USA.* Third harmonic generation by a femtosecond probe intersecting a laser-induced air plasma is measured and a general model developed to describe such signal. The electron density distribution and nonlinear coefficient of the plasma are determined.

CThFF3 • 17:15
Kilometer range filamentation: effects of filaments on transparent and non-transparent materials at long distances, *Magali Durand[1,2], Aurélien Houard[1], Bernard Prade[1], André Mysyrowicz[1], Anne Durécu[2], Didier Fleury[2], Bernard Moreau[2], Olivier Vasseur[2], Harmut Borchert[3], Karsten Diener[3], Rüdiger Schmitt[3], Françis Théberge[4], Marc Chateauneuf[4], Jacques Dubois[4]; [1]Laboratoire d'Optique Appliquée, ENSTA ParisTech, Ecole Polytechnique, CNRS, France; [2]Département d'Optique Théorique et Appliquée, ONERA, France; [3]Institut franco-allemand de recherches de Saint-Louis, France; [4]Defence Research and Development (DRDC), Canada.* We observe filamentation of a Terawatt laser beam after 1 km propagation in atmosphere. The white light generated was strong enough to saturate a CCD camera and damages on material were characterised.

CThFF4 • 17:30
High-Order Surface Harmonics Generated from Nanometer-Thick Foil Targets using a 40 TW Laser, *Crina A. Popovici[1], Sylvain Fourmaux[1], Ludovic Lecherbourg[2], Sebastien Buffechoux[1], Semen Gnedyuk[1], Francois Vidal[1], Jean-Claude Kieffer[1], Robin Marjoribanks[2], Tsuneyuki Ozaki[1]; [1]EMT, INRS, Canada; [2]Dept. of Physics, Univ. of Toronto, Canada.* We study the effect of energy of the pump laser on high-order harmonic generation (HHG) from foil targets as thin as 30 nm. We see that thinner targets generate harmonics with less background emission.

Room 337

CLEO: QELS-Fundamental Science

16:45–18:30
QThR • Quantum Optics with Quantum Dots
Edo Waks, Univ. of Maryland, USA, Presider

QThR1 • 16:45
Optically induced rotation of a quantum dot exciton spin, *Eilon Poem[1], Yaron Kodriano[1], Yael Benny[1], Stanislav Khatsevich[1], Oded Kenneth[1], Joseph Avron[1], David Gershoni[1]; [1]Technion, Israel.* A polarized picosecond laser pulse, which couples the bright exciton states to biexciton resonant states, is used to manipulate the exciton spin. We directly demonstrate this novel knob in a picosecond time-resolved two pulses experiment.

QThR2 • 17:00
Strong Interaction between Quantum Dot Exciton Spin States and a Photonic Crystal Cavity, *Hyochul Kim[1], Thomas C. Shen[1], Deepak Sridharan[1], Glenn Solomon[2], Edo Waks[1]; [1]ECE Dept., Univ. of Maryland, USA; [2]National Inst. of Standards and Technology, USA.* We apply a magnetic field to photonic crystal cavity devices with embedded Indium Arsenide (InAs) quantum dots (QDs), and demonstrate strong coupling between individual QD exciton spin states and a photonic crystal cavity.

QThR3 • 17:15
Off-resonant quantum dot-cavity interaction, *Arka Majumdar[1], Erik Kim[1], Yiyang Gong[1], Andrei Faraon[2], Dirk Englund[3], Jelena Vuckovic[1]; [1]Stanford Univ., USA; [2]Hp Labs, USA; [3]Columbia Univ., USA.* Off -resonant quantum dot -cavity coupling is studied both experimentally and theoretically. A theoretical model is proposed to explain the observations.

QThR4 • 17:30
Intensity damping of Rabi-oscillations and renormalization of the Rabi frequency in InGaAs/GaAs quantum dots, *Timothy M. Godden[1], Andrew J. Ramsay[1], Stephen J. Boyle[1], Erik M. Gauger[2], Ahsan Nazir[3], Brendon Lovett[2,4], Mark Fox[1], Maurice Skolnick[1]; [1]Physics and Astronomy, Univ. of Sheffield, UK; [2]Dept. of Materials, Univ. of Oxford, UK; [3]Physics and Astronomy, Univ. College London, UK; [4]School of Engineering and Physical Sciences, Heriot-Watt Univ., UK.* The source of intensity damping of Rabi-oscillations in quantum dots has long been in question. Here we identify acoustic phonons as the principal source of dephasing and demonstrate the re-normalization of the Rabi-frequency.

Room 338

CLEO: Science & Innovations

16:45–18:15
CThGG • Spatial Multiplexing and Crosstalk
René-Jean Essiambre, Bell Labs, Alcatel-Lucent, USA, Presider

CThGG1 • 16:45
Multiple-Input Multiple-Output with Predistortion and Signal Processing for Multimode Fiber Links, *Kumar Appaiah[1], Sriram Vishwanath[1], Seth R. Bank[1]; [1]Electrical and Computer Engineering, The Univ. of Texas at Austin, USA.* We demonstrate a multiple-input multiple-input multimode fiber optical link, where signal processing for dispersion compensation achieves a rate of 11.38 Gb/s over a 3 km fiber, exceeding the rated fiber bandwidth-length product by 15 times.

CThGG2 • 17:00
Propagation of Laguerre-Gaussian mode light through multi-core fiber at telecom wavelength, *Yoshinari Awaji[1], Naoya Wada[1], Yasunori Toda[2], Tetsuya Hayashi[3]; [1]National Inst. of information and communications technology, Japan; [2]Hokkaido Univ., Japan; [3]Sumitomo Electric Industries, Ltd., Japan.* We observed phase preservation of Laguerre-Gaussian light after propagation through multi-core fiber (7-core). We showed the possibility of mode-division multiplexing transmission in principle. Denser core promises higher degree of multiplexing.

CThGG3 • 17:15 Invited
Ultrafast and High-Spectral-Density Optical Communications Systems, *Masataka Nakazawa[1]; [1]Research Inst. of Electrical Communication, Tohoku Univ., Japan.* Recent progress on ultrafast coherent optical transmission toward 1 Tbit/s is overviewed, with a special focus on 640 Gbaud OTDM, 512 QAM with > 10 bit/s/Hz spectral density, and ultrafast, spectral-efficient transmission with an OTDM-RZ/QAM scheme.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

16:45–18:30
QThS • Linear and Nonlinear Wave Propagation
Alexander Szameit, Technion Israel Inst. of Technology, Israel, Presider

QThS1 • 16:45
Abruptly autofocusing waves, *Nikolaos K. Efremidis[1], Demetrios Christodoulides[2], Ioannis Chremmos[3], Zhigang Chen[4]; [1]Applied Mathematics, Univ. of Crete, Greece; [2]CREOL/College of Optics, Univ. of Central Florida, USA; [3]School of Electrical and Computer Engineering, National Technical Univ. of Athens, Greece; [4]Dept. of Physics and Astronomy, San Francisco State Univ., USA.* We introduce a new classes of waves that tend to autofocus in an abrupt fashion. These waves can be generated through the use of radially symmetric Airy waves.

QThS2 • 17:00
Demonstration of a Second-Order Nonlinear Silica Fiber Taper with Self-Assembled Organic Surface Layers, *Chalongrat Daengngam[1], Matthias Hofmann[2], Zhiwen Liu[3], Anbo Wang[2], Yong Xu[2], James R. Heflin[1]; [1]Physics, Virginia Tech, USA; [2]Electrical & Computer Engineering, Virginia Tech, USA; [3]Electrical Engineering, Pennsylvania State Univ., USA.* We present experimentally a novel technique to generate significant and thermodynamically stable second-order nonlinearity into a silica fiber taper by using nanoscale self-assembly of nonlinear molecules on a fiber surface.

QThS3 • 17:15
18-fold power reduction using Bragg grating-based switch in highly-nonlinear bismuth-oxide fiber, *Irina Kabakova[1], Dan Grobnic[2], Stephen Mihailov[2], C. Martijn de Sterke[1], Ben Eggleton[1]; [1]Univ. of Sydney, Australia; [2]Communications Research Centre Canada, Canada.* We experimentally demonstrate a Bragg grating-based all-optical switch in a highly nonlinear Bi2O3 fiber. We achieve 18-fold power reduction for a 6.5 dB switching ratio compared with previous demonstrations in silica fibers.

QThS4 • 17:30
Sub-natural Raman linewidth and high power CW Raman-Stokes laser in hydrogen filled HC-PCF, *Meshaal O. Alharbi[1,2], Anton Husakou[1,3], Fetah Benabid[1]; [1]Dept. of Physics, Univ. of Bath, UK; [2]Dept. of Physics and Astronomy, King Saud Univ., Saudi Arabia; [3]Max-Born-Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany.* We report on several tens of Watts CW Raman-Stokes in hydrogen gas with linewidth as low as 80 KHz. This represents a narrowing of the Raman-linewidth by a factor of more than 4 orders of magnitude.

16:45–18:30
QThT • Quantum Communication and Multipartite Entanglement
Timothy Ralph, Univ. of Queensland, Australia, Presider

QThT1 • 16:45 Invited
Continuous Variable Quantum Communication and Computation, *Ulrik L. Andersen[1], Ruifang Dong[1], Miroslav Jezek[1], Amine Laghaout[1], Mikael Lassen[1], Lars Madsen[1], Anders Tipsmark[1]; [1]Physics, Technical Univ. of Denmark, Denmark.* We use squeezed states of light to implement a robust continuous variable quantum key distribution scheme and an optical Hadamard gate based on coherent state qubits.

QThT2 • 17:15
Preparation and Local Manipulation of Photonic W States Using Expansion and Fusion Gates, *Sahin K. Ozdemir[1,2], Toshiyuki Tashima[1], Takashi Yamamoto[1], Masato Koashi[1], Nobuyuki Imoto[1]; [1]Osaka Univ., Japan; [2]Washington Univ. in St. Louis, USA.* We report experimental demonstration of an optical gate that increases the size of polarization-entangled W-states by accessing only one qubit, and discuss strategies of local expansion and fusion to prepare large scale W-state networks.

QThT3 • 17:30
Layered Architectural Design with Photonic Qubit Topological Cluster State Computation, *Bhaskar Roy Bardhan[1], Manish K. Gupta[1], Jonathan P. Dowling[1]; [1]LSU, USA.* We study the modular and layered framework to develop large scale quantum computer architecture with photonic qubits. A chip-based photonic module is integrated with the TCQC as depicted in [2] along with detailed analysis of resources.

16:45–18:30
CThHH • Waveguides and Passive Components
Brian Koch, Intel, USA, Presider

CThHH1 • 16:45
Low-loss Silicon-on-Diamond Optical Waveguides, *Di Liang[1], Marco Fiorentino[1], Shane T. Todd[2], Geza Kurczveil[2], Raymond G. Beausoleil[1], John E. Bowers[2]; [1]Intelligent Infrastructure Lab, HP Labs, USA; [2]Dept. of Electrical and Computer Engineering, Univ. of California, USA.* Low-loss optical rib waveguides (2.5 micron x 700 nm) have been fabricated on a silicon-on-diamond (SOD) substrate. 0.74 dB/cm propagation loss is measured. Benefits to heat dissipation for active photonic devices are studied.

CThHH2 • 17:00
Low-Loss Polysilicon Waveguides Suitable for Integration within a High-Volume Electronics Process, *Jason S. Orcutt[1], Sanh D. Tang[2], Steve Kramer[2], Hanqing Li[1], Vladimir Stojanovic[1], Rajeev J. Ram[1]; [1]Massachusetts Inst. of Technology, USA; [2]Micron Technologies, USA.* Polysilicon waveguides are fabricated in a 300 mm wafer process representative of a complete high-volume electronic memory process. 6.2 dB/cm end-of-line loss is measured for narrow waveguides with a confinement factor scaling of 5.1 cm^{-1}.

CThHH3 • 17:15
Suppression and control over the decay of a leaky mode through a transverse refractive index gradient, *Yonatan Plotnik[1], Or Peleg[1], Nimrod Moiseyev[2], Mordechai Segev[1]; [1]physics, Technion - Israel Inst. of Technology, Israel; [2]chemistry, Technion - Israel Inst. of Technology, Israel.* We demonstrate that the decay of leaky modes can be reduced by orders of magnitude, and controlled in a robust fashion, using a transverse refractive index gradient.

CThHH4 • 17:30
Novel Three-dimensional Hollow-core Waveguide Using High-contrast Sub-wavelength Grating, *Weijian Yang[1], James Ferrara[1], Karen Grutter[1], Anthony Yeh[1], Christopher Chase[1], Vadim Karagodsky[1], Devang Parekh[1], Yang Yue[2], Alan E. Willner[2], Ming Wu[1], Connie J. Chang-Hasnain[1]; [1]Dept. of Electrical Engineering and Computer Sciences, Univ. of California, Berkeley, USA; [2]Dept. of Electrical Engineering, Univ. of Southern California, USA.* A novel hollow-core waveguide using high-contrast sub-wavelength grating (HCG) is experimentally demonstrated for the first time. The waveguide is formed by two HCG planar structures and shows both transverse and lateral light confinement.

CLEO: QELS-Fundamental Science

QThP • Hyperbolic and Anistropic Metamaterial—Continued

QThP5 • 17:45
Spontaneous emission near hyperbolic metamaterials, *Zubin Jacob[1], Igor Smolyaninov[2], Evgenii Narimanov[3]; [1]Univ. of Alberta, Canada; [2]Univ. of Maryland, USA; [3]Purdue Univ., USA.* We show that there is an infinite local-density-of-states in the near-field of a hyperbolic metamaterial. This leads to spontaneous emission into metamaterial resonance cones opening the route to quantum-optics with metamaterials.

QThP6 • 18:00
Effect of Metallic and Hyperbolic Metamaterial Surface on Electric and Magnetic Dipole Emission, *Xingjie Ni[1], Gururaj V. Naik[1], Alexander V. Kildishev[1], Yuri A. Barnakov[2], Alexandra Boltasseva[1,3], Vladimir Shalaev[1]; [1]Birck Nanotechnology Center, School of Electrical and Computer Engineering, Purdue Univ., USA; [2]Center for Materials Research, Norfolk State Univ., USA; [3]DTU Fotonik, Technical Univ. of Denmark, Denmark.* Spontaneous emission patterns of electric and magnetic dipoles on different material surfaces were studied numerically and experimentally. The results show the modified behavior of electric and magnetic dipoles on metallic and HMM surfaces.

CLEO: Science & Innovations

CThZ • Novel Waveguides and Resonators—Continued

CThZ5 • 17:45
High Index Contrast Polymer Optical Waveguides, *Asael adler[1], Dan M. Marom[1]; [1]Applied physics Dept., Hebrew Univ. of Jerusalem, Israel.* We present the design of passive optical devices constructed with polymer platform, its fabrication and characterization. PFCB and Cytop polymers were chosen to offer low losses and high index contrast.

CThZ6 • 18:00
Characterization of Polymer Microtoroid Resonators Fabricated by Two-Photon Stereolithography Process, *Jee Soo Chang[1,2], Seung Hoon Lee[1], Yong Son[1], Prabhakaran Prem[3], Kwang-Sup Lee[3], Namkyoo Park[2], Dong-Yol Yang[1], Bumki Min[1]; [1]KAIST, Republic of Korea; [2]Seoul National Univ., Republic of Korea; [3]Hannam Univ., Republic of Korea.* We report on the fabrication and characterization of high-Q microtoroid resonators made of low-loss modified polymers by the two-photon stereolithography. We found that resonators can be fabricated in a high-speed process with maximum $Q=2.8\times10^5$.

CThZ7 • 18:15
Ultra-high-Q triangular cross-section nanobeam photonic cavities in single crystal diamond, *Igal Bayn[1], Boris Meyler[1], Joseph Salzman[1], Rafi Kalish[2]; [1]Dept. of Electrical Engineering, Technion, Israel; [2]Dept. of Physics, Technion, Israel.* A single crystal diamond nanobeam with a triangular cross-section and 1D-Bragg reflectors is reported. Modeling shows $Q\approx2.5\times10^6$, $Vm=1.06\times(\lambda/n)^3$. A low-Q cavity version was fabricated by Focused-Ion-Beam, exhibiting a clear mode confinement spectrum.

CThAA • Mode-Locked Solid State Lasers—Continued

CThAA4 • 17:45
High power, 60MHz, cryogenically cooled, mode-locked, Yb:YAG oscillator, *Michael Gerrity[1], Susannah Brown[1], Tenio Popmintchev[1], Ming-Chang Chen[1], Stefan Witte[1], Margaret M. Murnane[1], Henry C. Kapteyn[1], Sterling Backus[2]; [1]Univ. of Colorado, USA; [2]Kapteyn-Murnane Laboratories, USA.* We demonstrate a 60MHz, cryogenically cooled, mode-locked Yb:YAG oscillator with up to 12W average output power. Mode-locking is achieved via a SESAM, an intracavity SHG crystal, and an iris near focus for spatial mode filtering.

CThAA5 • 18:00
Compact 7.4 W femtosecond oscillator for white-light generation and nonlinear microscopy, *Andy Steinmann[1], Bernd Metzger[1], Robin Hegenbarth[1], Harald Giessen[1]; [1]4th Physics Inst. and Research Center SCOPE, Univ. of Stuttgart, Germany.* We present a passively mode-locked two-crystal Yb:KGW oscillator delivering 7.4 W average power at a repetition rate of 41.7 MHz and 425 fs pulse duration and demonstrate the generation of high-power supercontinua in tapered fibers.

CThAA6 • 18:15
Efficient Gigahertz Femtosecond Yb:KGW Laser with 2.2-W Average Power Generates Octave-Spanning Supercontinuum, *Selina Pekarek[1], Christian Fiebig[2], Katrin Paschke[2], Götz Erbert[2], Thomas Südmeyer[1], Ursula Keller[1]; [1]Dept. of Physics, Inst. of Quantum Electronics, ETH Zürich, Switzerland; [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Germany.* We present a 1-GHz Yb:KGW laser with 2.2-W average power and 38% optical- to-optical efficiency. The 290-fs pulses with 6.7-kW peak power generate an octave-spanning supercontinuum in a photonic-crystal-fiber.

CThBB • CLEO Symposium on Broadband Spectroscopy: New Techniques and Sources III: Sources—Continued

CThBB4 • 17:45
Characterization of a difference-frequency based mid-infrared comb source, *Tyler W. Neely[1], Todd Johnson[1], Scott Diddams[1]; [1]NIST, USA.* We characterize a broad bandwidth mid-IR comb source generated through difference frequency mixing of a Yb femtosecond fiber laser. The relationship between amplitude noise, timing jitter, and output power is explored.

CThBB5 • 18:00
Tunable Coherent Raman Soliton Generation with a Tm-Fiber System, *Jie Jiang[1], Axel Ruehl[1], Ingmar Hartl[1], Martin E. Fermann[1]; [1]IMRA America, Inc., USA.* We demonstrate wavelength tunable coherent Raman soliton generation in a Tm fiber amplifier seeded with a passively mode locked Tm fiber oscillator and subsequent octave spanning continuum generation in highly-nonlinear fibers.

18:30–20:00 Dinner Break

20:00–22:00 CLEO: 2011 Postdeadline Paper Sessions, *Rooms 316, 217 and 318-320*

NOTES

CLEO: Science & Innovations

CThCC • Gas Phase Sensing II—Continued

CThCC4 • 17:45
Shot-Noise Limited Sensitive Detection of OH Radicals by Faraday Rotation Spectroscopy at 2.8 µm, *Weixiong Zhao[1,2], Gerard Wysocki[3], Weidong Chen[1], Eric Fertein[1], David Le Coq[1], Denis Petitprez[4], Weijun Zhang[2]; [1]Université du Littoral Côte d'Opale, France; [2]Anhui Inst. of Optics and Fine Mechanics, China; [3]Princeton Univ., USA; [4]Université des Sciences et Technologies de Lille, France.* We report on the development of a Faraday rotation spectroscopy instrument using a DFB diode laser operating at 2.8 µm for the hydroxyl (OH) radical detection with a 1σ detection limit of 8.2×10^8 OH radicals/cm^3.

CThCC5 • 18:00
Effect of Speed of Sound on Quartz-Enhanced Photoacoustic Spectroscopy Trace Gas Sensor Performance, *Lei Dong[1], Kun Liu[1], Anatoliy A. Kosterev[1], Frank K. Tittel[1]; [1]Rice Univ., USA.* The effect of speed of sound (SoS) on the performance of quartz-enhanced photoacoustic spectroscopy (QEPAS) sensor was investigated. Methods to correct QEPAS signal and to minimize effect of SoS by the carrier gas was studied.

CThCC6 • 18:15
Probing of Multi Component Gas Samples by Means of Supercontinuum CRD-Spectrography, *Kamil Stelmaszczyk[1], Walter M. Nakaema[1], Zuoqiang Hao[1], Philipp Rohwetter[1], Ludger Woeste[1]; [1]Physics, Free Univ. Berlin, Germany.* The ring-down decay inside a high optical bandwidth cavity was excited by using the white light supercontinuum emitted from a photonic fiber to determine absorption properties of atmospheric air between 610-730 nm by means of the CRD-Spectrography.

CThDD • Pulsed Fiber Lasers—Continued

CThDD5 • 17:45
Rapidly tunable, wavelength agile, visible fiber based light source exploiting Raman scattering of multi-step pulses, *Shaif-ul Alam[1], Peh S. Teh[1], Dejiao Lin[1], Kangkang Chen[1], David J. Richardson[1]; [1]Optoelectronics Research Centre, Univ. of Southampton, UK.* We report a rapidly-tunable, wavelength-agile fiber laser exploiting stimulated Raman scattering of multi-step pump pulses which generates complex sequences of pulses of different wavelength.

CThDD6 • 18:00
Single Frequency Actively Q-Switched 2 µm Fiber Laser by Using Highly Tm-doped Germanate Fiber, *Wei Shi[1], Eliot B Petersen[1,2], Nick Moor[1,3], Arturo Chavez-Pirson[1], Nasser Peyghambarian[1,3]; [1]NP Photonics, Inc., USA; [2]Physics Dept., Univ. of Arizona, USA; [3]College of Optical Sciences, Univ. of Arizona, USA.* We report a unique all-fiber single-frequency actively Q-switched laser operating at ~1920 nm by using a piezo to press the fiber in the fiber Bragg grating cavity and modulate the fiber birefringence, enabling Q-switching.

CThDD7 • 18:15
Rapid, Wideband, Wavelength Tunable Narrow Linewidth Source by Spectral Compression of Ultrashort Soliton Pulses, *Norihiko Nishizawa[1], Koji Takahashi[2]; [1]Electrical Engineering and Computer Science, Nagoya Univ., Japan; [2]Advanced Science and Biotechnology, Osaka Univ., Japan.* Rapid, wideband, wavelength tunable narrow linewidth source was demonstrated by spectrum compression of Raman shifted ultrashort soliton pulses with comb profile fiber. High-speed near infrared absorption spectroscopy was demonstrated with it.

CThEE • THz Spectroscopy—Continued

CThEE5 • 17:45
Long Path (167 m) Broad-Band THz Transmission through the Atmosphere, *Yihong Yang[1], Mahboubeh Mandegar[1], Daniel R. Grischkowsky[1]; [1]Electrical Engineering, Oklahoma State Univ., USA.* We have transmitted low-power repetitive broad-band THz pulses the record distance of 167m through the atmosphere at 50% RH and have observed the broadened transmitted pulses with a S/N ratio greater than 200.

CThEE6 • 18:00
Long Tube Precise THz-TDS Measurement of the Transmission of the Atmosphere from 0.2 to 2 THz, *Yihong Yang[1], Alisha J. Shutler[1], Daniel R. Grischkowsky[1]; [1]Electrical Engineering, Oklahoma State Univ., USA.* The attenuation of the atmosphere in the range from low frequencies up to 2 THz is caused by water vapor. Here we report the most accurate measurement of this attenuation to date.

CThEE7 • 18:15
Long Path THz Detection of Small Molecule Vapors in the Atmospheric Transparency Windows, *Joseph S. Melinger[1], Yihong Yang[2], Alisha J. Shutler[2], Daniel R. Grischkowsky[2]; [1]Electronics Science and Technology Division, Naval Research Lab, USA; [2]School of Electrical and Computer Engineering, Oklahoma State Univ., USA.* We demonstrate the first phase of a long path THz-TDS apparatus to remotely detect the THz spectrum of small vapor phase molecules with rotational transitions that fall within the atmospheric transparency windows.

18:30–20:00 Dinner Break

20:00–22:00 CLEO: 2011 Postdeadline Paper Sessions, *Rooms 316, 217 and 318-320*

NOTES

CLEO: QELS-Fundamental Science

QThQ • Plasmon Optics—Continued

QThQ4 • 17:45
Optically Controlled Ultrafast Enhanced Transmission from a Sub-wavelength Aperture in a Planar Metal Film, *Mohamed A. Swillam[1], Nir Rotenberg[1], Henry M. van Driel[1]; [1]Dept. pf Physics, Univ. of Toronto, Canada.* We theoretically propose an ultrafast optical technique to control light emerging from a sub-wavelength aperture in a planar metal film through surface plasmon excitation by a transient-thermal grating.

QThQ5 • 18:00
Polychromatic nanofocusing of surface plasmons, *Wei Liu[1], Dragomir N. Neshev[1], Andrey E. Miroshnichenko[1], Ilya V. Shadrivov[1], Yuri S. Kivshar[1]; [1]Nonlinear Physics Centre, The Australian National Univ., Australia.* We introduce the concept of polychromatic plasmonics and demonstrate a broadband lens for nanofocusing of surface plasmons. This lens has a bandwidth more than an optical octave thus opening opportunities for broadband plasmonic applications.

QThQ6 • 18:15
Generation and Near-Field Imaging of Airy Plasmons, *Alexander Minovich[1], Angela E. Klein[2], Norik Janunts[2], Thomas Pertsch[2], Dragomir N. Neshev[1], Yuri S. Kivshar[1]; [1]NPC, Australian National Univ., Australia; [2]Inst. of Applied Physics, Friedrich-Schiller-Universität, Germany.* We demonstrate experimentally the generation and near-field imaging of propagating Airy plasmon beams. These self-accelerating plasmons exhibit self-healing properties and enable novel applications of plasmonics and surface optical tweezers.

CLEO: Science & Innovations

CThFF • Filamentation—Continued

CThFF5 • 17:45
Self-Accelerating Self-trapped Beams, *Ido Kaminer[1], Mordechai Segev[1], Demetrios Christodoulides[2]; [1]Physics Dept. and Solid State Inst., Technion, Israel; [2]CREOL - College of Optics & Photonics, Univ. of Central Florida, USA.* We present self-accelerating self-trapped beams in self-focusing and self-defocusing Kerr and saturable media. Such beams off-shoot solitons under strong self-focusing while their main lobe continues accelerating, and are stable otherwise.

CThFF6 • 18:00
Efficient third harmonic generation by two crossing filaments, *Magali Durand[1,2], Yi Liu[1], Aurélien Houard[1], Arnaud Couairon[3], André Mysyrowicz[1]; [1]Laboratoire d'Optique Appliquée, ENSTA ParisTech, Ecole Polytechnique, CNRS, France; [2]Département d'Optique Théorique et Appliquée, ONERA, France; [3]Centre de Physique Théorique, Ecole Polytechnique, CNRS, France.* Enhanced third harmonic by two crossing filaments is studied as function of pulse polarization, time delay, and interacting position. These systematic results point to the substantial role of the Gouy phase shift in the filament.

CThFF7 • 18:15
Digital Reverse Propagation in Focusing Kerr Media, *Alexandre Goy[1], Demetri Psaltis[1]; [1]Ecole Polytechnique Fédérale de Lausanne, Switzerland.* We report experimental image reverse propagation in focusing Kerr media. These results are compared with a linear Zernike filter operation. A method for the measurement of the nonlinear coefficient is derived from these results.

CLEO: QELS-Fundamental Science

QThR • Quantum Optics with Quantum Dots—Continued

QThR5 • 17:45
Fast high fidelity hole spin initialization in a single InGaAs quantum dot, *Timothy M. Godden[1], Stephen J. Boyle[1], Andrew J. Ramsay[1], Mark Fox[1], Maurice Skolnick[1]; [1]Physics and Astronomy, Univ. of Sheffield, UK.* A hole spin trapped in a quantum dot is a potential qubit. We demonstrate near unit fidelity initialization of a single hole spin in a InGaAs/GaAs Quantum dot.

QThR6 • 18:00
High-speed electrical control of a solid-state photonic quantum interface, *Antoine Boyer de la Giroday[1,2], Anthony J. Bennett[1], Matthew A. Pooley[1,2], Mark Stevenson[1], Niklas Skold[1], Raj B. Patel[1,2], Ian Farrer[2], David A. Ritchie[2], Andrew J. Shields[1]; [1]Toshiba Research Europe Ltd., UK; [2]Cavendish Lab, Univ. Of Cambridge, UK.* We demonstrate high-fidelity transfer of the polarisation of a photon into the spin-state of an electron-hole pair. Spins are then electrically manipulated on sub-nanosecond timescales and near-unity phase-shift and spin-flip gates are demonstrated.

QThR7 • 18:15
Optically generated 2-dimensional photonic cluster state from coupled quantum dots, *Sophia Economou[1], Netanel Lindner[2], Terry Rudolph[3]; [1]Naval Research Lab, USA; [2]Caltech, USA; [3]Imperial College London, UK.* We propose a deterministic approach for the generation of a 2D photonic cluster state from optically manipulated quantum dots. Our scheme can be implemented with existing technology. Error localization allows for quantum error correction.

CLEO: Science & Innovations

CThGG • Spatial Multiplexing and Crosstalk—Continued

CThGG4 • 17:45
Improving tolerance toward optical in-band crosstalk by employing a high pass filter, *Jeong Hwang[1], Joon-Young Kim[1], Hoon-Keun Lee[1], Chang-Hee Lee[1]; [1]KAIST, Republic of Korea.* We propose a guideline of HPF (high pass filter) for improving tolerance toward optical in-band crosstalk in WDM-PON. A cut-off frequency of HPF should be higher than five times of linewidth for effectively reducing crosstalk.

CThGG5 • 18:00
Dual Functional Optical Amplifier with Electrooptic Gain Medium of Er^{3+} Doped PLZT Ceramics, *Jingwen W. Zhang[1], Haibin Sun[1], Hua Zhao[1], Yingyin Zou[2], Kewen Li[2], Hua Jiang[2]; [1]Physics, Harbin Inst. of Technology, China; [2]Boston Applied Technologies, Inc., USA.* A novel dual functional device combining optical filtering and amplification by taking advantage of excellent electrooptic property in the gain medium was designed and demonstrated in covering both C- and L-bands.

18:30–20:00 Dinner Break

20:00–22:00 CLEO: 2011 Postdeadline Paper Sessions, *Rooms 316, 217 and 318-320*

NOTES

CLEO: QELS-Fundamental Science

QThS • Linear and Nonlinear Wave Propagation—Continued

QThS5 • 17:45
Interferometry with Vacuum-amplified Waveforms, *Utsab Khadka[1], Huaibin Zheng[1], Min Xiao[1]; [1]Physics, Univ. of Arkansas, USA.* Coexisting four-wave-mixing processes are observed via atomic coherence. The controllable phase and interference between these vacuum-amplified radiations look promising for applications including waveform-shaping and high-resolution metrology.

QThS6 • 18:00
Time-reversed Lasing and Control of Absorption in a Two-channel Coherent Perfect Absorber, *Wenjie Wan[1], Yidong Chong[1], Li Ge[1], Heeso Noh[1], A Douglas Stone[1], Hui Cao[1]; [1]Applied Physics, Yale Univ., USA.* We demonstrate a novel mechanism for controlling absorption of coherent light bytwo orders of magnitude. By varying the phase of incident laser light in a two-port geometry, the absorption is greatly enhanced or reduced.

QThS7 • 18:15
Observation of auto-focusing radially symmetric Airy beams, *Peng Zhang[1], Jai Prakash[1], Ze Zhang[2,1], Yi Hu[3], Nikos Efremidis[4], V. Kajorndejnukul[2], Demetrios Christodoulides[2], Zhigang Chen[1,3]; [1]Dept. of Physics and Astronomy, San Francisco State Univ, USA; [2]CREOL/College of Optics, Univ. of Central Florida, USA; [3]TEDA Applied Physics School, Nankai Univ, China; [4]Dept. of Applied Mathematics, Univ. of Crete, Greece.* We demonstrate optical beam auto-focusing without the need of a focusing lens or nonlinearity. Radial Airy beams with inward and outward accelerations are used and an abrupt transition between Airy and Bessel behavior is observed.

QThT • Quantum Communication and Multipartite Entanglement—Continued

QThT4 • 17:45
Projection of Two Biphoton Qutrits onto a Maximally Entangled State, *Assaf Halevy[1], Eli Megidish[1], Tomer Shacham[1], Liat Dovrat[1], Hagai S. Eisenberg[1]; [1]Racah Inst. of Physics, The Hebrew Univ. of Jerusalem, Israel.* We propose and demonstrate the projection of two quantum three state systems (qutrits) onto a maximally entangled state. The qutrits are represented by the polarization of biphotons - pairs of indistinguishable photons.

QThT5 • 18:00
Conservation of Vacuum in an Interferometer, *Dominic W. Berry[1], Alexander I. Lvovsky[2]; [1]Inst. for Quantum Computing, Univ. of Waterloo, Canada; [2]Inst. for Quantum Information Science, Univ. of Calgary, Canada.* We provide a systematic method of quantifying the amount of loss a multimode optical state has experienced. We show that it is not possible to concentrate the non-vacuum components via linear optics.

QThT6 • 18:15
Two-way Secure Communication Using Quantum Illumination, *Maria Tengner[1], Tian Zhong[1], Franco Wong[1], Jeffrey H. Shapiro[1]; [1]Research Lab of Electronics, Massachusetts Inst. of Technology, USA.* A two-way entanglement-based communication protocol resilient to high loss and noise is implemented. Even though the entanglement is lost during transmission, efficient communication that is secure against passive eavesdropping is possible.

CLEO: Science & Innovations

CThHH • Waveguides and Passive Components—Continued

CThHH5 • 17:45
A Platform for Three-dimensional On-chip Photonics: Multi-bonded Silicon-On-Insulator wafers, *Amir Hosseini[1], Babak Fallahazad[1], David Kwong[1], Yang Zhang[1], Emanuel Tutuc[1], Ray T. Chen[1]; [1]ECE, Univ. of Texas at Austin, USA.* We propose a novel platform for three dimensional photonics. A double layer 1x12 multimode interference coupler is fabricated on a double-bounded Silicon-on-insulator wafer. Optical characterizations confirm low insertion loss and uniform outputs.

CThHH6 • 18:00
Integrated Temporal Fourier Transformer Based on Chirped Bragg Grating Waveguides, *Ksenia Dolgaleva[1], Antonio Malacarne[2], Pamela Tannouri[2], Luis A. Fernandes[1,3], Jason R. Grenier[1], J. Stewart Aitchison[1], Jose Azana[2], Roberto Morandotti[2], Peter R. Herman[1], Paulo V. Marques[3]; [1]Electrical and Computer Engineering, Univ. of Toronto, Canada; [2]Institut National de la Recherche Scientifique, Canada; [3]Departamento de Fisica e Astronomia, Universidade do Porto, Portugal.* We experimentally realized an integrated temporal Fourier transformer based on a linearly-chirped Bragg grating waveguide written in silica glass with a femtosecond laser. The device operates in reflection and has a 10-nm bandwidth.

CThHH7 • 18:15
Add-Drop Filter Incorporating a Mode-Conversion Cavity, *Marcel W. Pruessner[1], Jacob B. Khurgin[2], Todd H. Stievater[1], Robert Bass[1], William S. Rabinovich[1], John B. Boos[1], Vincent J. Urick[1]; [1]Naval Research Lab (NRL), USA; [2]Electrical & Computer Engineering, Johns Hopkins Univ. (JHU), USA.* We demonstrate a new add-drop filter architecture combining an asymmetric Y-branch mode conversion waveguide and a high index contrast shifted grating mode-conversion cavity. Measurements show add-drop functionality in a linear Fabry-Perot filter.

18:30–20:00 Dinner Break

20:00–22:00 CLEO: 2011 Postdeadline Paper Sessions, *Rooms 316, 217 and 318-320*

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