Room A1 | Room A2 | Room A3 | Room A4

CLEO: Science & Innovations

08:00–10:00
CF1A • Organic Emitters and Absorbers
Uriel Levy, Hebrew University of Jerusalem, Israel, *Presider*

CF1A.1 • 08:00 Invited
Delayed Fluorescence by Reverse Intersystem Crossing and Applications to Organic Light-Emitting Diodes, Kenichi Goushi[1]; [1]*Kyushu University, Japan.* Organic donor and acceptor interfaces give rise to a small energy gap between the singlet and triplet exciton levels (ΔEST) of generated exciplexes. We demonstrate that the small ΔEST can lead to efficient electroluminescence.

CF1A.2 • 08:30
Enhanced photostability of aqueous solution of Rhodamine 6G with gold nanoparticles in lasing process by silica coating, Lin Dong[1], Fei Ye[1], Adnan Chughtai[1], Sergei Popov[1], Ari T. Friberg[1,2], Mamoun Muhammed[1]; [1]*Royal Institute of Technology, Sweden, Sweden;* [2]*Aalto University, Finland.* Gold nanoparticles are mixed in aqueous solution of Rhodamine 6G to modify the lasing output intensity. The photostability deterioration of the gain medium by gold nanoparticles is successfully compensated by silica coating on the nanoparticles.

08:00–10:00
CF1B • Novel Application of Nonlinear Optics
Shekhar Guha, US Airforce Research Lab, USA, *Presider*

CF1B.1 • 08:00
Pump-probe microscopy of pigments used in historical art, Prathyush Samineni[1], Adele deCruz[1], Tana Villafana[1], Martin C. Fischer[1], Warren S. Warren[1,2]; [1]*Chemistry, Duke University, USA;* [2]*Radiology, Biomedical engineering, Duke University, USA.* We have developed a nonlinear microscopy technique that uses sensitive modulation transfer to extract excited state dynamics with high spatial resolution. Here, we use this technique to characterize several pigments used in historical artwork.

CF1B.2 • 08:15
Three-Dimensional Mapping of Transparent Objects Using Kerr Nonlinearity Measurement, Alexandre Goy[1], Demetri Psaltis[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* We report a technique to produce three-dimensional maps of transparent objects using the Kerr coefficient as a contrast agent. The method is based on the spatial modifications of a probe pattern focused into the medium.

CF1B.3 • 08:30
Homodyne Near-Degenerate Four-Wave-Mixing Microscopy for Graphene Imaging and Biomedical Applications, Baolei Li[1], Congwen Yi[3], April S. Brown[3], Martin C. Fischer[2], Warren S. Warren[2,4]; [1]*Physics, Duke University, USA;* [2]*Chemistry, Duke University, USA;* [3]*Electrical and Computer Engineering, Duke University, USA;*[4]*Biomedical Engineering, Duke University, USA.* Homodyne detection of near-degenerate four-wave-mixing with a single laser pulse is used to imaging graphene in biological samples.

08:00–10:00
CF1C • EUV Metrology
Jason Jones, University of Arizona, *Presider*

CF1C.1 • 08:00
Femtosecond Enhancement Cavity EUV Source with High Energy Resolution, Matthew H. Lam[1], Arthur K. Mills[1], Egor Chasovskikh[1], David J. Jones[1]; [1]*Physics and Astronomy, University of British Columbia, Canada.* A table-top EUV source based on a femtosecond enhancement cavity is seeded by a 1040-nm Yb-doped fiber amplifier system with 185-fs pulses and produces >10 microwatts/harmonic at 80 MHz out to 55 nm.

CF1C.2 • 08:15
Optical Coherence Tomography using broadbandwidth XUV and soft x-ray radiation, Silvio Fuchs[1,2], Alexander Blinne[1], Christian Rödel[1,2], Ulf Zastrau[1], Vinzenz Hilbert[1], Martin Wünsche[1], Jana Bierbach[1], Eckhart Förster[1], Gerhard Paulus[1,2]; [1]*Institute of Optics and Quantum Electronics, University of Jena, Germany;* [2]*Helmholtz Institute Jena, Helmholtz Institute Jena, Germany.* We report on the extension of Optical Coherence Tomography using extreme ultraviolet and soft x-ray radiation and demonstrate an axial resolution of nanometers.

CF1C.3 • 08:30
Thin film characterization using third harmonic generation microscopy, Cristina Rodriguez[1], Reed Weber[1], Duy Nguyen[1], Luke A. Emmert[1], Dinesh Patel[2], Carmen Menoni[2,3], Wolfgang Rudolph[1]; [1]*Department of Physics and Astronomy, University of New Mexico, USA;* [2]*Department of Electrical Engineering, Colorado State University, USA;* [3]*Department of Chemistry, Colorado State University, USA.* TH microscopy is applied to determine susceptibilities of films and image nascent, laser incubated, and laser damaged dielectric coatings with unprecedented contrast. The relative contribution of signals from film and surroundings is analyzed.

CLEO: QELS-Fundamental Science

08:00–10:00
QF1D • Engineered Plasmonic Surfaces
Cameron Smith, Danmarks Tekniske Universitet, Denmark, *Presider*

QF1D.1 • 08:00
Dynamically routing surface plasmon polaritons along arbitrary trajectories, Peng Zhang[1,2], Sheng Wang[1], Yongmin Liu[1], Xiaobo Yin[1,3], Changgui Lu[1], Zhigang Chen[2,4], Xiang Zhang[1,3]; [1]*NSF Nanoscale Science and Engineering Center, University of California, Berkeley, USA;* [2]*Department of Physics and Astronomy, San Francisco State University, USA;* [3]*Materials Science Division, Lawrence Berkeley National Laboratory, USA;* [4]*TEDA Applied Physics School, Nankai University, China.* We show how surface plasmon polaritons can be routed along arbitrary trajectories by forming nondiffracting Airy beams on metal surfaces. The dynamic computer-based control over such plasmonic Airy beams is demonstrated in our experiment.

QF1D.2 • 08:15
Plasmonic-based techniques to generate and detect optical vortex beams, Patrice Genevet[1,2], Jiao Lin[1], Nanfang Yu[1], Francesco Aieta[1], Mikhail A. Kats[1], Romain Blanchard[1], Zeno Gaburro[1], Marlan O. Scully[2], Federico Capasso[1]; [1]*Harvard University-SEAS, USA;* [2]*Texas A&M University, USA.* Ultra-thin and integrated photonic devices based on optical phase discontinuities can generate optical vortices with a variety of topological charges, as well as sort out vortex beam topological charges by means of holographic gratings.

QF1D.3 • 08:30
Demonstration of a new type of two-dimensional nondiffracting surface plasmon polariton, Jiao Lin[1,2], Jean Dellinger[3], Patrice Genevet[1,4], Benoit Cluzel[3], Frederique de Fornel[3], Marlan O. Scully[4], Federico Capasso[1]; [1]*Harvard University, USA;* [2]*Singapore Institute of Manufacturing Technology, Singapore;* [3]*Institut Carnot de Bourgogne, France;* [4]*Texas A&M University, USA.* We introduce a new type of nondiffracting surface plasmon polaritons: the cosine-Gauss beam (CGB). We prove both theoretically and experimentally that CGB is a nondiffracting solution to the two-dimensional wave equation.

Room A5

CLEO: QELS-Fundamental Science

08:00–10:00
QF1E • Quantum Optics Using Quantum Dots
Ranojoy Bose, University of Maryland, USA, *Presider*

QF1E.1 • 08:00
Charge switching dynamics and optimal excitation wavelength of single NV centers in ultrapure diamond, Anton Batalov[1], Katja Beha[1], Neil Manson[2], Rudolf Bratschitsch[1], Alfred Leitenstorfer[2]; *[1]University of Konstanz, Germany; [2]Laser Physics Centre, Australian National University, Australia.* Photoluminescence excitation spectra of single NV centers in diamond are studied and an optimal wavelength for NV– is found. The physics of bidirectional switching between NV0 and NV– charge states of the defect is elucidated.

QF1E.2 • 08:15
Engineering of radiative and non-radiative channels in colloidal nanocrystals: towards Room-temperature efficient colloidal quantum sources, Godefroy Leménager[1], Ferruccio Pisanello[2,3], Luigi Martiradonna[2], Luigi Carbone[3], Pascal Desfonds[1], Jean-Pierre Hermier[5], Elisabeth Giacobino[1], Roberto Cingolani[2], Massimo De Vittorio[2,4], Alberto Bramati[1]; *[1]ENS, UPMC, CNRS, Laboratoire Kastler Brossel, France; [2]Center for Bio-Molecular Nanotechnology, Istituto Italiano di Tecnologia, Italy; [3]Center for Neuroscience and Cognitive Systems @UNITN, Istituto Italiano di Tecnologia, Italy; [4]CNR-Nano, Università del Salento, Dipartimento Ingegneria dell'innovazione, National Nanotechnology Laboratory, Italy; [5]CNRS UMR8635, Université de Versailles, Saint-Quentin-en-Yvelines, Groupe d'étude de la Matière Condensée, France.* Blinking effect and multi-excitonic emission can be independently addressed by tuning both core and shell dimension. By confocal techniques measurement, we show dot-in-rods as blinking-free sources of single photon on demand at room temperature.

QF1E.3 • 08:30
Single Quantum Dot Locked to Atomic Transition, Nika Akopian[1], R. Trotta[2], E. Zallo[2], A. Rastelli[2], O. Schmidt[2], V. Zwiller[1]; *[1]Kavli Institute of Nanoscience Delft, Netherlands; [2]Institute for Integrative Nanosciences, Germany.* We tune and lock the exciton emission energy of a single quantum dot to an atomic transition. The locking precision of few micro-eV can allow for single charge sensing, spectral diffusion counteraction, and energy stabilization schemes.

Room A6

CLEO: Science & Innovations

08:00–09:30
CF1F • Coherent Communications
Christian Malouin, Juniper Networks Inc., USA, *Presider*

CF1F.1 • 08:00 Invited
The Age of Optical Coherent Communication, Kuang-Tsan (KT) Wu[1], Han (Henry) Sun[1], John McNicol[1], Matthew Mitchell[2], Vinayak Dangui[2], Mike VanLeeuvan[3], Jeff Rahn[2], Steve Grubb[3], Radha Nagarajan[2], Mehrdad Ziari[2], Scott Corzine[2], Pete Evans[2], Masaki Kato[2], Fred Kish[2], Dave Welch[2]; *[1]Infinera Canada, Canada; [2]Infinera, USA; [3]Infinera, USA.* Recent emergence of coherent optical modem has solved a number of difficult problems in optical transmission, resulting in 10x increase in capacity. The latest research of super-channels further increases spectral efficiency and network flexibility.

CF1F.2 • 08:30
Frequency Offset Estimation in M-QAM Coherent Optical Systems Using Phase Entropy, Stefanos Dris[1], Ioannis Lazarou[1], Paraskevas Bakopoulos[1], Hercules Avramopoulos[1]; *[1]School of Electrical and Computer Engineering, National Technical University of Athens, Greece.* A novel approach for Frequency Offset Estimation in coherent optical M-QAM systems using the received symbol phase entropy is investigated. It is accurate, non-data-aided, oblivious to modulation format and requires no gain control.

Room A7

CLEO: QELS-Fundamental Science

08:00–10:00
QF1G • Spatial and Temporal Solitons
Matteo Lab, INRS-EMT, Canada, *Presider*

QF1G.1 • 08:00
Higher-order Modulation Instability in Optical Fibers, Miro Erkintalo[1,2], Kamal Hammani[3], Bertrand Kibler[3], Christophe Finot[3], Nail Akhmediev[4], John M. Dudley[5], Goëry Genty[1]; *[1]Tampere University of Technology, Finland; [2]University of Auckland, New Zealand; [3]Université de Bourgogne, France; [4]The Australian National University, Australia; [5]Université de Franche-Comté, France.* We report on theoretical, numerical and experimental study of a new form of instability in a nonlinear fiber. This process of higher-order modulation instability arises from the nonlinear superposition of elementary instability dynamics.

QF1G.2 • 08:15
Plasma-induced soliton self-frequency blueshift in gas-filled hollow-core PCFs, Mohammed F. Saleh[1], Fabio Biancalana[1], Philipp Hoelzer[1], Wonkeun Chang[1], John C. Travers[1], Nicolas Joly[1], Philip S. Russell[1]; *[1]NPN, Max Planck Institute for the Science of Light, Germany.* We present new equations describing pulse envelope propagation in a hollow-core PCF filled with an ionizable gas. We describe for the first time the recently observed plasma-induced soliton self-frequency blueshift.

QF1G.3 • 08:30
Experimental investigation of dispersion-managed soliton interaction, Alexander Hause[1], Philipp Rohrmann[1], Fedor Mitschke[1]; *[1]Institut fuer Physik, Universitaet Rostock, Germany.* Dispersion-managed solitons can form stable molecules. Systematically mapping out parameter space using a flexible pulse shaper, we investigate the binding mechanism and confirm predictions. Phenomena off equilibrium are also described and explained.

Room A8

CLEO: QELS-Fundamental Science

08:00–09:45
QF1H • Disordered and Random Media
Ayman Abouraddy, CREOL, USA , *Presider*

QF1H.1 • 08:00
Self-Imaging through a Disordered Waveguide Lattice, Robert Keil[1], Yoav Lahini[2], Yoav Shechtman[3], Matthias Heinrich[1], Rami Pugatch[2], Felix Dreisow[1], Andreas Tünnermann[1], Stefan Nolte[1], Alexander Szameit[1]; *[1]Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [2]Department of Physics of Complex Systems, The Weizmann Institute of Science, Israel; [3]Physics Department and Solid State Institute, Technion, Israel.* We demonstrate that the eigenmodes of a waveguide array with disorder in the coupling between adjacent guides are pairwise conjugated. Therefore, self-imaging via phase-segmentation is inherently insensitive to such an off-diagonal disorder.

QF1H.2 • 08:15
Optimal Spatiotemporal Focusing Through Complex Scattering Media, Jochen Aulbach[1,2], Alice Bretage[2], Mathias Fink[2], Mickael Tanter[2], Arnaud Tourin[2]; *[1]Center for Nanophotonics, FOM Institute AMOLF, Netherlands; [2]Institut Langevin, ESPCI ParisTech, CNRS, France.* We demonstrate, based on spatial and frequency resolved wave front shaping with a nonlinear feedback signal, how to achieve optimal spatiotemporal focusing through a complex scattering medium.

QF1H.3 • 08:30
Lasing in Thue-Morse structure with optimal aperiodicity, Jin-Kyu Yang[1,2], Heeso Noh[1], Svetlana V. Boriskina[3], Michael J. Rooks[1], Glenn S. Solomon[4], Luca Dal Negro[3], Hui Cao[1]; *[1]Applied Physics, Yale University, USA; [2]Optical Engineering, Kongju National University, Republic of Korea; [3]Electrical and Computer Engineering, Boston University, USA; [4]Joint Quantum Institute, NIST, USA.* We demonstrated lasing in two-dimensional Thue-Morse structures fabricated in InAs quantum dots embedded GaAs membrane. We optimized structural aperiodicity by gradually changing the relative size of two scatters for the strongest light confinement.

Room B2 & B3 | Room C1 & C2 | Room C3 & C4

CLEO: Science & Innovations

08:00–10:00
CF1I • Optofluidics: "Lab on a Chip"
Michael Previte, Illumina, USA, *Presider*

CF1I.1 • 08:00
Lensfree Imaging of Dense Samples using Holograms Recorded at Multiple Heights, Alon Greenbaum[1], Aydogan Ozcan[1,2]; *[1]Electrical Engineering Department, University of California, Los Angeles, USA; [2]Bioengineering Department, University of California, Los Angeles, USA.* Multi-height phase recovery and pixel super-resolution enable lensfree on-chip holographic imaging of dense and confluent Papanicolaou smears over a large field-of-view (24-30mm2) with sub-micron resolution.

CF1I.2 • 08:15
Fluorescent flow-cytometry on a cell-phone, Hongying Zhu[1], Aydogan Ozcan[1]; *[1]UCLA, USA.* We demonstrate fluorescent imaging flow-cytometry that is integrated on a cell-phone. The cell-phone based flow-cytometer was used to measure the density of white-blood-cells in blood samples, providing a decent match to the hematology analyzer.

CF1I.3 • 08:30
Diffractive Optofluidic Imaging Flow Cytometry, Ethan Schonbrun[1], Sai Siva Gorthi[1], Diane Schaak[1]; *[1]Rowland Institute, Harvard University, USA.* We integrated a diffractive lens array into a microfluidic channel array to produce a parallel flow-based cell imaging platform. Using the system, we demonstrate imaging with submicron resolution at throughputs surpassing 10,000 cells per second.

08:00–10:00
CF1J • Photovoltaics Fundamentals and Concepts
Mikael Syväjärvi, Linköpings Universitet, Sweden, *Presider*

CF1J.1 • 08:00 Tutorial
Tutorial on Solar Energy, Ryne Raffaelle[1]; *[1]Rochester Institute of Technology, USA.* The solar industry has grown at an astonishingly high rate over the past decade. This growth has been both in what one could consider the "traditional" areas such as flat panel crystalline silicon arrays, as well as in "new" technologies such as thin film CdTe arrays on glass. We will review some of the major discoveries of the past and trace how the industry came to be where it is today. We will also provide an overview of some of the latest discoveries in the field and what are the current hot areas of interest. Finally, we will discuss what these current trends industry may hold for the future, both technically and from a business perspective for this very rapidly developing field.

Dr. Ryne P. Raffaelle is the Vice President for Research and Associate Provost at Rochester Institute of Technology (RIT). Prior to his current position, he served as the Director of the National Center for Photovoltaics at the National Renewable Energy Lab of the U.S. Department of Energy, from 2009 through 2011. Before joining NREL, Dr. Raffaelle was the Academic Director for the Golisano Institute for Sustainability at RIT. He is also the Emeritus Director of the NanoPower Research Laboratory, a laboratory which he founded at RIT in 2001. He currently holds appointments as a Professor of Physics, Imaging Science, Microsystems Engineering, and Sustainability. As a professor, he has been responsible for more than $20 million in research grants in photovoltaics, batteries, and nanomaterials research. His career includes working as a visiting scientist at the NASA-Glenn Research Center; the NASA Lewis Research Center; and at Oak Ridge National Laboratory. He was a Professor of Physics and Space Sciences at the Florida Institute of Technology from 1992-1999. Dr. Raffaelle has authored or co-authored over 200 refereed publications and books. He is the Managing Editor of Progress in Photovoltaics published by Wiley Interscience. He is currently serving on the organizing committee for the IEEE Photovoltaics Specialists Conference, is a member of the AIAA Technical Committee on Aerospace Power, and is a member of the IEC/IEEE Joint Project Team (JPT) 62659 (IEEE 1784). He has a Ph.D. in Physics from University of Missouri-Rolla, and Bachelor of Science and Master of Science degrees in Physics from Southern Illinois University.

08:00–10:00
CF1K • Short Wavelength Quantum Cascade Lasers
Alexey Belyanin, Texas A&M, USA, *Presider*

CF1K.1 • 08:00
Single-Frequency kHz-Linewidth 2-µm GaSb-Based Semiconductor Disk Lasers With Multiple-Watt Output Power, Sebastian Kaspar[1], Marcel Rattunde[1], Tino Töpper[1], Christian Manz[1], Klaus Köhler[1], Joachim Wagner[1]; *[1]Fraunhofer-Institute for Applied Solid States Physics, Germany.* A 1-W output power single-frequency 2.05-µm semiconductor disk laser with a linewidth of 20 kHz (60 kHz) by Pound-Drever-Hall wavelength stabilization (without active wavelength stabilization) is demonstrated.

CF1K.2 • 08:15
External cavity tuning of broadband quantum cascade saser active region designs around 3.3 µm and 8 µm, Sabine S. Riedi[1], Alfredo Bismuto[1], Andreas Hugi[1], Stéphane Blaser[1], Mattias Beck[1], Jerome Faist[1]; *[1]Physics, QOE, IQE, ETH Zurich, Switzerland.* Broadband-Quantum-Cascade-Lasers around 3.3 µm and 8 µm regions were tuned over 277 wavenumbers and 445 wavenumbers respectively using an external-cavity set-up. The devices were HR and AR coated and operated in pulsed mode.

CF1K.3 • 08:30 Invited
Improved Interband Cascade Lasers for $\lambda = 3$-5.6 µm, Chadwick L. Canedy[1], Chulsoo Kim[1], Charles Merritt[1], William W. Bewley[1], Joshua Abell[1], Igor Vurgaftman[1], Jerry R. Meyer[1], Mijin Kim[2]; *[1]Code 5613, Naval Research Laboratory, USA; [2]Sotera Defense Solutions, USA.* The cw operating temperature of ICLs emitting at 3.9, 4.7 and 5.6 µm is extended to 107°C, 60°C, and 48°C, respectively. The threshold powers range from several tens to several hundred mW at 25°C.

CLEO: Science & Innovations

Marriott San Jose Salon I & II

08:00–10:00
CF1L • High Harmonic and Diffractive Imaging
Charles Durfee, Colorado School of Mines, USA, *Presider*

CF1L.1 • 08:00
Scaling of High Harmonic Generation with Visible Driver Wavelengths, Chien-Jen Lai[1], Giovanni Cirmi[1,2], Eduardo Granados[1,3], Shu-Wei Huang[1], Phillip D. Keathley[1], Alexander Sell[1], Kyung-Han Hong[1], Jeffrey Moses[1], Franz X. Kaertner[1,2]; *[1]MIT, USA; [2]CFEL, DESY and Univ of Hamburg, Germany; [3]Basque Foundation for Science, Spain.* The wavelength scaling of high harmonic generation efficiency and cutoff is studied with different visible driver wavelengths from a tunable optical parametric amplifier. A lambda-5.9 scaling relation for the efficiency is measured.

CF1L.2 • 08:15
Unified Microscopic-Macroscopic Picture of High Harmonic Generation from the VUV to the keV X-ray Region, Tenio Popmintchev[1], Dimitar Popmintchev[1], Ming-Chang Chen[1], Jonathas P. Siqueira[2], Carlos Hernandez-Garcia[3], Jose A. Perez-Hernandez[4], Luis Plaja[3], Andreas Becker[1], Agnieszka Jaron-Becker[1], Skirmantas Alisauskas[5], Giedrius Andriukaitis[5], Audrius Pugzlys[5], Andrius Baltuska[5], Margaret M. Murnane[1], Henry C. Kapteyn[1]; *[1]JILA, University of Colorado at Boulder, USA; [2]Instituto de Física de São Carlos, Universidade de São Paulo, Brazil; [3]Grupo de Investigación en Óptica Extrema, Universidad de Salamanca, Spain; [4]Centro de Láseres Pulsados, CLPU, Spain; [5]Photonics Institute, Vienna University of Technology, Austria.* We present a unified picture of phase matching of high harmonic upconversion spanning the electromagnetic spectrum from the VUV to keV, combining both microscopic and macroscopic physics. We validate this picture with experiment and theory.

CF1L.3 • 08:30
Intense vacuum-ultraviolet single-order harmonic pulse by a deep-ultraviolet driving laser, Shunsuke Adachi[1,2], Takuya Horio[1,3], Toshinori Suzuki[1,3]; *[1]Kyoto University, Japan; [2]Japan Science and Technology Agency, PRESTO, Japan; [3]Advanced Science Institute, RIKEN, Japan.* A 90-nm single-order harmonic pulse with a 100-nJ pulse energy was realized by the frequency-tripling of 35-fs Ti:Sa third harmonic in a krypton gas cell.

Marriott San Jose Salon III

08:00–10:00
CF1M • Photonic Crystals I
Jean-Michel Gerard, CEA/INAC/SP2M, France, *Presider*

CF1M.1 • 08:00 Invited
Cavity QED with Anderson-Localized Cavities in Disordered Photonic Crystals, Peter Lodahl[1], P. David Garcia[1]; *[1]Niels Bohr Institute, University of Copenhaguen, Denmark.* We review recent experiments on the use of disordered photonic crystals for enhancing light-matter interaction. Coupling single quantum dots to Anderson-localized modes enables cavity quantum electrodynamics with random cavity modes.

CF1M.2 • 08:30
Off-resonant Coupling Between a Single Quantum Dot and a Nanobeam Photonic Crystal Cavity, Armand Rundquist[1], Jelena Vuckovic[1], Arka Majumdar[1]; *[1]E. L. Ginzton Laboratory, Stanford University, USA.* We demonstrate off-resonant coupling between a single quantum dot and a nanobeam photonic crystal cavity, under resonant excitation of the dot or the cavity. We confirm that this is an incoherent phonon-mediated process.

Marriott San Jose Salon IV

08:00–10:00
CF1N • Ultrafast Fiber Lasers
Shinji Yamashita, University of Tokyo, Japan, *Presider*

CF1N.1 • 08:00
Picosecond pulses from an FDML laser, Christoph M. Eigenwillig[1], Sebastian Todor[2], Wolfgang Wieser[1], Benjamin Biedermann[1], Thomas Klein[1], Christian Jirauschek[2], Robert Huber[1]; *[1]Chair of BioMolecular Optics, Ludwig-Maximilians-University München, Germany; [2]Institute for Nanoelectronics, Technische Universität München, Germany.* We present a comparison between theory and experiment for the generation of short pulses from FDML lasers. The theory predicts that in the future bandwidth limited pulse might be possible.

CF1N.2 • 08:15
Pulse Repetition Rate Control of Asynchronous Mode-Locked Fiber Lasers without Changing the Cavity Length, Siao-Shan Jyu[1]; *[1]Photonics, National Chiao Tung University, Taiwan.* A new method for fine-controlling the mode-locked laser repetition rate without changing the cavity length is proposed and demonstrated on a 10GHz asynchronous mode-locked Er-fiber soliton laser through the EO modulation strength adjustment.

CF1N.3 • 08:30 Invited
Modeling and Power Scaling of Carbon-Nanotube Mode-Locked Fiber Lasers, Norihiko Nishizawa[1]; *[1]Electrical Engineering and Computer Science, Nagoya University, Japan.* Dynamics of Er-doped ultrshort pulse fiber laser with carbon nanotube were investigated both experimentally and numerically. The highest output power of 114 mW and pulse energy of 3.5 nJ were achieved by optimization of cavity.

Room A1 | Room A2 | Room A3 | Room A4

CLEO: Science & Innovations

CF1A • Organic Emitters and Absorbers—Continued

CF1A.3 • 08:45
Nd^{3+}-TFA:HPDA Polymeric Microchip Laser, Hiroaki Yoshioka1, Wataru Iwasaki2, Yukihiko Yamashita2, Nobuo Miyadera2, Kei Yasui3, Daisuke Maeda3, Yuji Oki1; 1Graduate School of Information Science and Electrical Engineering, Kyushu University, Japan;2Hitachi Chemical Co., Ltd., Japan; 3Nissan Chemical Industries, Ltd., Japan. We demonstrated a Nd3+ complex doped solid-state polymer laser. The laser threshold was reduced to 334 μJ with a new solid-state host matrix and a short laser cavity. Its low threshold enables LD pumping operation.

CF1A.4 • 09:00
***Z*-scan Measurements of the Excited State Absorption Cross Sections of a Benzothiazolylfluorenylethynyl-Substituted Terpyridyl Platinum(II) Complex,** Timothy M. Pritchett[1], Wenfang Sun[2], Bingguang Zhang[2], Yunjing Li[2], Joy E. Haley[3]; [1]*U.S. Army Research Laboratory, USA;* [2]*Department of Chemistry and Biochemistry, North Dakota State University, USA;* [3]*Materials and Manufacturing Directorate, Air Force Research Laboratory, USA.* Using Z scans employing 4.1-ns and 21-ps pulses, values of 4.0 × 10-17 cm2 and 4.2 × 10-17 cm2 were obtained for the singlet and triplet excited-state absorption cross sections of a novel terpyridyl platinum(II) chloride complex at 532 nm.

CF1A.5 • 09:15
Nonlinear Optical Characterization of Chromophore-functionalized POSS Nanoparticles in a Polymeric Host, David J. McGee[1], Johannes Schleusener[2], Yuta Saito[3], Padma Gopalan[3]; [1]*Physics, The College of New Jersey, USA;* [2]*Physics, Beuth University of Applied Sciences, Germany;* [3]*Materials Science and Engineering, University of Wisconsin-Madison, USA.* Chromophore-functionalized polyhedral oligomeric silsesquioxane (POSS) was blended with a polycarbonate host and spin cast into films with < 1.5 dB/cm loss at 1550 nm. The films were poled to a stable d33 of 35 pm/V.

CF1A.6 • 09:30
Highly Linear Electro-optic Polymer Based Traveling Wave MMI-fed Directional Coupler Modulator, Xingyu Zhang[1], Beomsuk Lee[1], Che-yun Lin[1], Alan Wang[2], Amir Hosseini[3], Ray T. Chen[1]; [1]*Microelectronics Research Center, Electrical and Computer Engineering Department, University of Texas at Austin, USA;* [2]*School of Electrical Engineering & Computer Science, Oregon State University, USA;* [3]*Omega Optics, Inc., USA.* We demonstrate an EO polymer based traveling-wave MMI-fed directional-coupler modulator. High-speed and linear operation is demonstrated with bandwidth-length product of 125GHz*cm, the 3-dB electrical bandwidth of 10GHz, and the SFDR of 110±3dB/Hz2/3.

CF1B • Novel Application of Nonlinear Optics—Continued

CF1B.4 • 08:45
Fiber Optical Parametric Frequency Conversion: Alignment and Maintenance Free All-fiber Laser Concept for CARS Microscopy, Martin Baumgartl[1], Mario Chemnitz[1], Cesar Jauregui[1], Thomas Gottschall[1], Tobias Meyer[2], Benjamin Dietzek[2], Jürgen Popp[2], Jens Limpert[1], Andreas Tünnermann[1]; [1]*Institute of Applied Physics, Friedrich-Schiller-Universität, Germany;* [2]*Institut für Photonische Technologien e.V., Germany.* We present the development of a parametric all-fiber laser source for CARS microscopy. Since the pump and Stokes wavelengths are generated by four-wave-mixing, both pulses are emitted from a single fiber end with intrinsic synchronization.

CF1B.5 • 09:00
Balanced-detection Raman induced Kerr effect microscopy, Vikas Kumar[1], Michele Casella[1], Egle Molotokaite[1], Philipp Kukura[2], Cristian Manzoni[1], Dario Polli[1], Marco Marangoni[1], Giulio Cerullo[1]; [1]*Physics, Politecnico di Milano, Italy;* [2]*Oxford University, United Kingdom.* We introduce balanced-detection Raman-induced Kerr effect microscopy as a new powerful coherent Raman imaging technique, combining background-free detection with the absence of non-resonant background and linear dependence on sample concentration.

CF1B.6 • 09:15
Frequency-doubled Supercontinuum for Scanning White-light Interferometry, Piotr Ryczkowski[1], Goëry Genty[1], Anton Nolvi[2], Ivan Kassamakov[2], Edward Haeggström[2]; [1]*Tampere University of Technology, Finland;* [2]*University of Helsinki, Finland.* We present a compact, broadband source with tunable repetition rate working in the visible/near-infrared for scanning white-light interferometry. Three-dimensional characterization of MEMS with 7 micron axial resolution is demonstrated.

CF1B.7 • 09:30
Impact of Phase-Sensitive-Amplifier's Mode Structure on Amplified Image Quality, Muthiah Annamalai[1], Michael Vasilyev[1], Prem Kumar[2]; [1]*Electrical Engineering, University of Texas at Arlington, USA;* [2]*EECS, Northwestern University, USA.* We study phase-sensitive image pre-amplification versus pumping conditions and number of signal modes. We see image improvement by pre-amplification, and high-spatial-frequency enhancement for "higher-order-pump," "nonzero-wavevector-mismatch" cases.

CF1C • EUV Metrology—Continued

CF1C.4 • 08:45
Table-top Time-resolved Extreme Ultraviolet Nano-holography Scheme, Erik B. Malm[1], Christopher G. Brown[1], Przemyslaw W. Wachulak[2], Jorge Rocca[1], Carmen Menoni[1], Mario Marconi[1]; [1]*Electrical Engineering, Colorado State University, USA;* [2]*Institute of Optoelectronics, Military University of Technology, Poland.* We describe the implementation of a time-resolved high resolution Fourier holographic imaging system. Spatial resolution below 100 nm and temporal resolution of 1 ns may be achieved utilizing a compact table-top extreme ultraviolet laser.

CF1C.5 • 09:00 Invited
Toward a Nuclear Optical Clock, Corey Campbell[1]; [1]*Georgia Tech, USA.* The extension of coherent state manipulation and precision laser spectroscopy and metrology from atomic to nuclear states would be a tremendous advance in fundamental physics research. The 7.6 eV isomeric transition in the 229Th nucleus is currently the sole candidate for such an extension.

CF1C.6 • 09:30
Doppler-Free Two-Photon Direct Frequency Comb Spectroscopy With Coherent Control, Itan Barmes[1], Stefan Witte[1], Kjeld Eikema[1]; [1]*LaserLab, Vrije Universiteit, Netherlands.* We demonstrate a method to eliminate Doppler effects in femtosecond pulse excitation using coherent control. This enables high-precision direct frequency comb spectroscopy using significantly simplified setups and is compatible with XUV applications.

CLEO: QELS-Fundamental Science

QF1D • Engineered Plasmonic Surfaces—Continued

QF1D.4 • 08:45
Steering Surface Plasmons on Metal Surface, Tao Li[1], Lin Li[2], Shining Zhu[2]; [1]*College of Engineering and Applied Sciences, Nanjing University, China;* [2]*School of Physics, Nanjing University, China.* We proposed a new approach to modulate the beam phase of propagating surface Plasmon polariton (SPP) wave by in-plane diffractions, so as to steer SPP beam property. SPP Airy beams and broadband focusing were realized.

QF1D.5 • 09:00
Frequency Selective Vertical Nanoplasmonic Interconnects, Michael Nielsen[1], Abdul Y. Elezzabi[1]; [1]*Electrical and Computer Engineering, University of Alberta, Canada.* A nanoscale silicon plasmonic device was examined for vertical integration of nanoplasmonic circuits through vertically coupled ring resonators. Devices with planar footprints as small as 1.00μm2 were examined for frequency selective signal tansfer.

QF1D.6 • 09:15
Experimental demonstration of bosonic quantum interference of single surface plasmon polaritons, Go Fujii[1,2], Akito Fujikake[1], Naoto Namekata[1], Daiji Fukuda[2], Shuichiro Inoue[1]; [1]*Institute of Quantum Science, Nihon University, Japan;* [2]*National Institute of Advanced Industrial Science and Technology, Japan.* We have demonstrated the quantum interference with single surface plasmon polaritons (SSPPs) excited via single-photons. The result indicates the bunching of two SSPPs, which is the evidence that the quantum interference of SSPPs is bosonic.

QF1D.7 • 09:30
Transmission enhancement with the array of faced folded metallic rods embedded in a metallic slit, Taerin Chung[1], Yongjun Lim[1], Seung-Yeol Lee[1], Byoungho Lee[1]; [1]*Seoul National University, Republic of Korea.* We propose that the array of plasmonic faced folded rods (FFR) enhances transmission of light in a narrow metallic slit. The functionality is shown by the use of optical microscopy which provides far-field intensity images.

Room A5

CLEO: QELS-Fundamental Science

QF1E • Quantum Optics Using Quantum Dots—Continued

QF1E.4 • 08:45
Enhanced Probing of Fermion Interaction by Weak Value Amplification, Alex Hayat[1], Amir Feizpour[1], Aephraim Steinberg[1]; *[1]University of Toronto, Canada.* We propose a scheme for weak-value amplification of probing a single-fermion interaction, and demonstrate it theoretically on quantum dot electron spins by mapping the state including energy and spin into a photon.

QF1E.5 • 09:00
Elastic and Inelastic Light Scattering from a Quantum Dot, Kumarasiri Konthasinghe[1], J. Walker[1], M. Peiris[1], C.k. Shih[2], Y. Yu[3], M. Li[3], J. He[3], H. Ni[3], Z. Niu[3], Andreas Muller[1]; *[1]Physics, University of South Florida, USA; [2]University of Texas at Austin, USA; [3]Chinese Academy of Sciences,, China.* We spectrally resolve the light scattered by a single InAs semiconductor quantum dot and analyze the relative contribution of elastic and inelastic scattering processes.

QF1E.6 • 09:15
Resonant biexciton quantum-dot cavity coupling and its potential for a fast 1.55-µm-telecom-band single photon source, Muhammad Danang Birowosuto[1], Hisashi Sumikura[1], Shinji Matsuo[2], Hideaki Taniyama[1], Peter van Veldhoven[3], Richard Nötzel[3,4], Masaya Notomi[1]; *[1]NTT Basic Research Laboratories, NTT Corporation, Japan; [2]NTT Photonics Laboratories, NTT Corporation, Japan; [3]COBRA Research Institute, Eindhoven University of Technology, Netherlands; [4]Institute for Systems based on Optoelectronics and Microtechnology, Technical University of Madrid, Spain.* We report a fast and Purcell-enhanced single photon source at 1.55 µm from a biexciton of a single quantum dot coupled with a photonic crystal nanocavity. Purcell enhancement of five times is demonstrated.

QF1E.7 • 09:30
Bright single photon emission from a quantum dot in a circular dielectric grating, Serkan Ates[1,2], Luca Sapienza[1], Marcelo Davanco[1,2], Antonio Badolato[3], Kartik Srinivasan[1]; *[1]Center for Nanoscale Science and Technology, National Institute of Standards and Technology, USA; [2]Maryland NanoCenter, University of Maryland, USA; [3]Department of Physics and Astronomy, University of Rochester, USA.* We demonstrate a single photon source based on a single quantum dot in a circular grating microcavity and measure a collection efficiency of 10%. Tradeoffs between suppressed multi-photon probability and Purcell enhancement are investigated.

Room A6

CLEO: Science & Innovations

CF1F • Coherent Communications—Continued

CF1F.3 • 08:45
Frequency Offset Estimation in a Polarization-Multiplexed Coherent OFDM system stressed by chromatic dispersion and PMD, Julie Karaki[1], Erwan Pincemin[1], Yves Jaouën[2], Raphaël Le Bidan[3]; *[1]CORE/TPN, France Telecom, Orange Labs, France; [2]Telecom ParisTech, Institut Telecom, France; [3]Telecom Bretagne, Institut Telecom, France.* We propose here a simple method to estimate carrier frequency offset (CFO) in a polarization-multiplexed coherent OFDM (CO-OFDM) system.

CF1F.4 • 09:00
Coherent Matched Detection with Multi-Input-Multi-Output Equalization for Demultiplexing/Demodulation of Orthogonally Time/Frequency Domain Multiplexed Signal, Takahide Sakamoto[2,1]; *[1]Natl Inst Info & Commctn Tech, Japan; [2]UC Davis, USA.* We investigate optical coherent matched detection with MIMO equalization implemented. Coherent mismatching between signal and local combs is mitigated, demultiplexing ultrafast and high-spectral-efficiency OTFDM signals with improved orthogonality.

CF1F.5 • 09:15
A Novel Double-Sided Multiband Direct-Detection Optical OFDM System with Single Laser Source, Kai-Ming Feng[1], Jhih-Heng Yan[1], Yuan-Wei Chang[2], Fu-Lien Cheng[2]; *[1]Institute of Photonics Technologies, National Tsing Hua University, Taiwan; [2]Institute of Communications Engineering, National Tsing Hua University, Taiwan.* We proposed and experimentally demonstrated a double-sided multiband DDO-OFDM system requiring only half of the total signal bandwidth in the receiver. The experimental results match the simulations well for all the signal bands.

Room A7

CLEO: QELS-Fundamental Science

QF1G • Spatial and Temporal Solitons—Continued

QF1G.4 • 08:45
Raman-free Soliton Self Frequency Shift in Photonic Crystal Waveguides, Pierre Colman[1], Sylvain Combrié[1], Stefano Trillo[2], Alfredo De Rossi[1]; *[1]Thales Research & Technology, France; [2]Universita di Ferrara, Italy.* Cherenkov radiation and Soliton Self Frequency Shift are reported in (1.5mm-long) Photonic Crystal waveguides. The picosecond and picojoule pulses used here and the absence of Raman-induced frequency shift are peculiar of this new nonlinear material.

QF1G.5 • 09:00
Three-dimensional spatial solitons in CS2, Edilson L. Falcao-Filho[1], Cid B. de Araujo[1], Georges Boudebs[2], Herve Leblond[2], Vladimir Skarka[2]; *[1]Departamento de Fisica, Universidade Federal de Pernambuco, Brazil; [2]Laboratoire de Photoniques d'Angers, Université d`Angers, France.* Three-dimensional spatial solitons excited by near-infrared femtosecond pulses in CS2 are demonstrated. The propagation of such stable solitons is allowed due to the presence of the fifth-order nonlinearity which prevented the catastrophic collapse.

QF1G.6 • 09:15
Nonlinear Spectral Symmetry Breaking of Light Bullets in Waveguide Arrays, Falk Eilenberger[1], Stefano Minardi[1], Alexander Szameit[1], Ulrich Röpke[2], Jens Kobelke[2], Kay Schuster[2], Hartmut Bartelt[2], Stefan Nolte[1], Andreas Tuennermann[1], Thomas Pertsch[1]; *[1]Institute of Applied Physics, Friedrich-Schiller-Universität, Abbe Center of Photonics, Germany; [2]Institute of Photonic Technology, Germany.* We investigate the wavelength dependence of the diffraction on Light Bullets. This dependence gives rise to spatiotemporal coupling and spatiotemporally modified spectra. This nonlinear spectral reshaping is measured and analyzed.

QF1G.7 • 09:30
Incoherent Embedded Solitons, Maxim Kozlov[1], Oren Cohen[1]; *[1]Physics, Technion, Israel.* We show that a partially coherent beam can be self-trapped into an incoherent soliton with all its coherent components embedded in the continuum. Incoherent embedded solitons display distinctive power spectrum and coherence properties.

Room A8

CLEO: QELS-Fundamental Science

QF1H • Disordered and Random Media—Continued

QF1H.4 • 08:45
Focusing through disordered media inside a laser cavity, Micha Nixon[1], Ori Katz[1], Eran Small[1], Asher Friesem[1], Yaron Silberberg[1], Nir Davidson[1]; *[1]Weizmann Institute of Science, Israel.* A new concept for focusing light through a randomly disordered media is demonstrated. Results show how by placing the randomly scattering media directly into a laser cavity tight focusing is accomplished in less than 600ns.

QF1H.5 • 09:00
Ultra-compact High-resolution On-chip Spectrometer Based on Random Nanostructures, Brandon Redding[1], Jing Ma[2], Hui Cao[1]; *[1]Applied Physics, Yale University, USA; [2]Agiltron, Inc, USA.* We design and fabricate an on-chip spectrometer based on random arrays of scatterers. Multiple scattering of light increases the effective optical pathlength, allowing us to dramatically reduce the device size without sacrificing spectral resolution.

QF1H.6 • 09:15
Observation of super-ballistic transport in hybrid ordered/disordered photonic lattices, Simon Stützer[1], Tsampikos Kottos[2], Andreas Tünnermann[1], Stefan Nolte[1], Demetrios N. Christodoulides[3], Alexander Szameit[1]; *[1]Institute of Applied Physics, Friedrich-Schiller-Universität, Germany; [2]Department of Physics, Wesleyan University, USA; [3]College of optics and Photonics, University of Central Florida, USA.* We observe superballistic transport in optical lattices where a finite disordered region embed- ded into a periodic structure acts as a light source of constant flux, boosting the spread of a wavepacket.

QF1H.7 • 09:30
Random laser in totally disordered 2D GaAs/AlGaAs heterostructures, Antoine Monmayrant[3,4], Olivier Gauthier-Lafaye[3,4], Sophie Bonnefont[3,4], Shivakiran Bhaktha[2], Christian Vanneste[2], Nicolas Bachelard[1], Patrick Sebbah[1], Françoise Lozes-Dupuy[3,4]; *[1]Institut Langevin, ESPCI Paristech, France; [2]LPMC, CNRS, France; [3]LAAS, CNRS, France; [4]UPS, INSA, Université Toulouse, France.* We demonstrate random lasing emission in AlGaAs suspended membrane randomly perforated with subwavelength circular holes. Spectrally-resolved imaging of the lasing emission allows identifying lasing modes in the diffusive regime.

Room B2 & B3

CLEO: Science & Innovations

CF1I • Optofluidics: "Lab on a Chip"—Continued

CF1I.4 • 08:45
Digital Petri Dish for On-chip Cell Monitoring, Guoan Zheng[1], Seung Ah Lee[1], Xiaoze Ou[1], Changhuei Yang[1]; *[1]Electrical Engineering, Caltech, USA.* We report a digital Petri dish platform for on-chip cell monitoring. We demonstrate the ability to image confluent cell cultures with 6 mm × 4 mm filed-of-view and ~0.7 µm resolution by using the proposed platform.

CF1I.5 • 09:00 Tutorial
Chip-scale Microscopy Imaging, Guoan Zheng[1] and Changhuei Yang[1], *[1]Caltech, USA.* We will discuss the design strategies and recent developments of chip-scale microscopy approaches, including digital in-line holography, optofluidic microscopy and self-imaging digital Petri dish platform.

Guoan Zheng received his B.S. degree from Zhejiang University, China in 2007 and his M.S. degree from California Institute of Technology in 2008, all in electrical engineering. Currently, he is a PhD student in the Biophotonics Lab at Caltech. His expertise is in biomedical optics and micro/nano technologies, and has over 18 peer-reviewed publications and 6 patents. In his PhD career, he developed many innovative tools for biological imaging, including the digital Petri dish, subpixel optofluidic microscope and plasmonic darkfield aperture. His current research interest is to use computational optical sensing and imaging methods to develop cost-effective high-throughput microscopy modalities. He was the recipient of Lemelson-MIT Caltech student prize in 2011 for his contribution on cost-effective microscopy solutions.

Room C1 & C2

CF1J • Photovoltaics Fundamentals and Concepts—Continued

CF1J.2 • 09:00
CIGS solar cell integrated with high mobility microcrystalline Si TFTs on 30X40 cm2 glass panels for self powered electronics, Chang-Hong Shen[1], Jia-Min Shieh[1,2], Tsung-Ta Wu[1], Jung Y. Huang[2], Che-Hsuan Huang[2], Yu-Hsiang Huang[2], Tien-Chang Lu[2], Bau-Tong Dai[1], Chenming Hu[3], Fu-Liang Yang[1]; *[1]National Nano Device Laboratories, Taiwan; [2]Department of Photonics and Institute of Electro-Optical Engineering, National Chiao Tung University, Taiwan; [3]Dept. of Electrical Eng. and Computer Science, University of California, USA.* For the first time, we report a self-powered TFT panel (30X40cm2) by integration of sputtering/non-toxic Se vapor selenization CIGS solar cell (conversion efficiency of 8%) and high electron-mobility (172 cm2/V-s) micro-crystalline (uc)-Si TFTs.

CF1J.3 • 09:15
Ultrafast Pump-probe Spectroscopy of Carrier Relaxation Dynamics in Cu(In,Ga)Se2 Thin Films, Shih-Chen Chen[1], Yu-Kuang Liao, Hsueh-Ju Chen[1], Hao-Chung Kuo[2], Kaung-Hsiung Wu[1], Takayoshi Kobayashi[1]; *[1]Department of Electrophysics, National Chiao Tung University, Taiwan; [2]Department of Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Taiwan; [3]Compound Semiconductor Solar Cell Department, Next Generation Solar Cell Division, Green Energy and Environment Research Laboratories, Industrial Technology Research Institute, Taiwan.* Ultrafast pump-probe spectroscopy of Cu(In,Ga)Se2 thin films was performed. We have found the non-radiative recombination dominated at room temperature. It could correlate to efficiency of Cu(In,Ga)Se2-based solar cells.

CF1J.4 • 09:30
Accurate measurement of the external quantum efficiency of multi-junction solar cells, Jing-Jing Li[1], Yong-Hang Zhang[1]; *[1]Arizona State University, USA.* A pulsed voltage bias method is used to accurately measure the external quantum efficiency (EQE) of multi-junction solar cells by controlling the electrical and optical coupling between subcells.

Room C3 & C4

CF1K • Short Wavelength Quantum Cascade Lasers—Continued

CF1K.4 • 09:00
Continuous-Wave Operation of Type-I GaSb-based Narrow Ridge Waveguide Lasers near 3254nm, James Gupta[1], Pedro J. Barrios[1], Andrew Bezinger[1], Philip Waldron[1]; *[1]National Research Council of Canada, Canada.* Narrow ridge waveguide (5um) laser diodes were fabricated using type-I InGaAsSb/AlInGaAsSb quantum well active regions on GaSb. The devices operate in continuous-wave mode near 3254nm with a total light output of 7.4mW at 20°C (uncoated facets).

CF1K.5 • 09:15
62 mW Output Power, Room-Temperature Operation, CW Interband Cascade Laser, Geunmin Ryu[1], Jeyran Amirloo[1], Simarjeet Saini[2], Fred Towner[3], Mario Dagenais[1]; *[1]Electrical and Computer Engineering, University of Maryland, USA; [2]Department of Electrical and Computer Engineering and Waterloo Institute of Nanotechnology, University of Waterloo, Canada; [3]Maxion Technologies, Inc., USA.* We report an output power of 62mW in an interband cascade laser operated cw at room-temperature (T = 20°C), with an internal loss of 4.9cm-1, and a threshold current density as low as 320A/cm2.

CF1K.6 • 09:30
3190 - 3275 nm tuneable, Room temperature, external cavity InAs/AlSb Quantum Cascade Laser, Tomasz Kruczek[1], Edik Rafailov[1], Ksenia A. Fedorova[1], Alexei Baranov[2], Roland Teissier[2]; *[1]School of Engineering, Physics and Mathematics, University of Dundee, United Kingdom; [2]Institut d'Électronique du Sud, CNRS / Université Montpellier 2, France.* We demonstrated a room temperature, tuneable, external cavity Quantum Cascade Laser for the use in compact spectroscopic gas sensing system. Wavelength tuning of 85nm between 3190nm and 3275nm was achieved at room temperature.

Marriott San Jose Salon I & II | Marriott San Jose Salon III | Marriott San Jose Salon IV

CLEO: Science & Innovations

CF1L • High Harmonic and Diffractive Imaging—Continued

CF1L.4 • 08:45
Coherent Diffraction Imaging with an Apertured Illumination Support, Bosheng Zhang[1], Dennis Gardner[1], Leigh S. Martin[1], Matthew E. Seaberg[1], Daniel E. Adams[1], Margaret M. Murnane[1], Henry C. Kapteyn[1]; *[1]Physics department, JILA, University of Colorado at Boulder, USA.* We demonstrate coherent diffraction imaging (CDI) using the projected image of an aperture as a support. This method is strikingly simple and allows CDI imaging of non-isolated objects in transmission and reflection.

CF1L.5 • 09:00
Complete spatio-temporal characterization of collimated high-power femtosecond lasers, Valentin Gallet[1], Fabien Quéré[1]; *[1]Physique haute intensité, CEA, France.* To obtain complete spatio-temporal characterizations of high-power femtosecond lasers, we apply SEA TAPDOLE to collimated beams. We show how to correct phase fluctuations in the fiber interferometer, which is essential in this configuration.

CF1L.6 • 09:15
Generalized Multishearing Interferometry for the Complete Multidimensional Characterization of Optical Beams and Ultrashort Pulses, Adam S. Wyatt[1], Jens Biegert[2], Ian A. Walmsley[1]; *[1]Departmet of Physics, Clarendon Laboratory, United Kingdom; [2]Insitut de Ciencies Fotoniques, Spain.* We demonstrate increased accuracy and precision in the reconstruction of the multidimensional phase of electromagnetic fields based on multiple spectral shearing interferometry measurements made with shears of an arbitrary magnitude.

CF1L.7 • 09:30
Fresnel-regime coherent diffractive imaging with with a 13 nm high harmonic source, Richard L. Sandberg[1], Dennis Gardner[2], Matthew E. Seaberg[2], Daniel E. Adams[2], Henry C. Kapteyn[2], Margaret M. Murnane[2], John L. Barber[3]; *[1]Center for Integrated Nanotechnology, Materials Physics and Applications Division, Los Alamos National Laboratory, USA; [2]Department of Physics and JILA, University of Colorado at Boulder and NIST, USA; [3]Theoretical Division, Los Alamos National Laboratory, USA.* Coherent x-ray diffractive imaging (CXDI) is a powerful technique for wavelength-limited, ultrafast images. We present a novel analysis and demonstration of Fresnel-regime (near field) CXDI with a tabletop 13 nm high harmonic generation source.

CF1M • Photonic Crystals I—Continued

CF1M.3 • 08:45
Efficient Lasing with Nanocrystal Quantum Dots Using Purcell Effect to Overcome Auger Recombination, Shilpi Gupta[1], Edo Waks[1]; *[1]Electrical and Computer Engineering, University of Maryland College Park, USA.* We theoretically investigate the use of small mode-volume cavity in overcoming Auger recombination in NQDs by Purcell enhancement, and show lasing with high output efficiency (>0.75) and high spontaneous emission coupling factor (>0.9).

CF1M.4 • 09:00
Ultrafast Direct Modulation of a Single-Mode Photonic Crystal Nanocavity Light-Emitting Diode, Gary Shambat[1], Bryan Ellis[1], Arka Majumdar[1], Jan Petykiewicz[1], Marie Mayer[2], Tomas Sarmiento[1], James Harris[1], Eugene Haller[2], Jelena Vuckovic[1]; *[1]Stanford University, USA; [2]Berkeley, USA.* We demonstrate an electrically driven single mode photonic crystal cavity LED with record speed of operation (10 GHz) and 0.25 fJ/bit energy consumption, the lowest of any optical transmitter to date.

CF1M.5 • 09:15
Effects of Non-Lasing Band in 2D Photonic Crystal Lasers, Kazuyoshi Hirose[1,2], Yoshitaka Kurosaka[1,2], Akiyoshi Watanabe[1], Takahiro Sugiyama[1], Susumu Noda[2]; *[1]Central Research Laboratory, Hamamatsu Photonics K. K., Japan; [2]Department of Electronic Science and Engineering, Kyoto University, Japan.* We investigate the effects of a non-lasing band in photonic-crystal lasers. We found that the non-lasing band may scatter the laser beam despite wavenumber mismatch, which leads to the generation of weak dual-veined beam patterns.

CF1M.6 • 09:30
Lasing action from organic two-dimensional planar photonic crystal microcavity, Francois Gourdon[1], Mahmoud Chakaroun[1], Nathalie Fabre[1], Sophie Bouchoule[2], Alexis Fischer[1], Alejandro Giacometti[2], Azzedine Boudrioua[1], Gregory Barbillon[1], Jeanne Solard[1]; *[1]Laboratoire de Physique des Lasers, France;[2]Laboratoire de Photonique et Nanostructures 6 LPN / CNRS, France.* Lasing in organic 2D photonic crystal microcavity is investigated under optical pumping of Alq3:DCJTB as a gain medium. The resonant mode of the microcavity was measured at 662 nm with a threshold of 0.6 nJ/pulse.

CF1N • Ultrafast Fiber Lasers—Continued

CF1N.4 • 09:00
Double-wall carbon nanotube Q-switched and mode-locked two-micron fiber lasers, Fengqiu Wang[1], Zhe Jiang[1], Tawfique Hasan[1], Zhipei Sun[1], Daniel Popa[1], Felice Torrisi[1], Wonbae Cho[1], Emmanuel Flahaut[2,3], Andrea C. Ferrari[1]; *[1]Engineering Department, Cambridge University, United Kingdom; [2]Institut Carnot Cirimat, Université de Toulouse; UPS, INP, France; [3]Institut Carnot Cirimat, CNRS, France.* We fabricate double-wall carbon nanotube polymer composite saturable absorbers and demonstrate stable Q-switched and Mode-locked Thulium fiber lasers in a linear cavity and a ring cavity respectively.

CF1N.5 • 09:15
Stretched-Pulse Mode-locking using a Mechanically Exfoliated Graphene Saturable Absorber, Amos Martinez[1], Shinji Yamashita[1]; *[1]The University of Tokyo, Japan.* We demonstrate stretched-pulse modelocking using a saturable absorber fabricated by mechanical exfoliation of graphene. Such saturable absorber offers advantages such as ease of fabrication and robustness to optical damage under high intensities.

CF1N.6 • 09:30
High Energy Amplifier Similariton Laser Based on Integrated Chirally-coupled Core Fiber, Simon Lefrancois[1], Chi-Hung Liu[2], Thomas S. Sosnowski[2], Almantas Galvanauskas[3], Frank W. Wise[1]; *[1]Applied Physics, Cornell University, USA; [2]Arbor Photonics Inc., USA; [3]Electrical Engineering and Computer Science, University of Michigan, USA.* We present an amplifier similariton laser based on chirally-coupled core fiber. Chirped pulse energies up to 60 nJ are obtained with compressed durations below 90 fs. We demonstrate an integrated pump-signal combiner for chirally-coupled fibers.

Room A1	Room A2	Room A3	Room A4

CLEO: Science & Innovations

CF1A • Organic Emitters and Absorbers—Continued

CF1A.7 • 09:45

Excitonic energy transfer dynamics in hybrid organic/inorganic nanocomposites at high loading levels, Burak Guzelturk[1], Pedro Ludwig Hernandez Martinez[1], Donus Tuncel[2], Hilmi Volkan Demir[1,3]; [1]*Electrical and Electronics Engineering, Bilkent University, Turkey;* [2]*Chemistry, Bilkent University, Turkey;* [3]*School of Electrical and Electronics Engineering, Nanyang Technological University, Singapore.* Temperature dependent exciton migration in the hybrid nanocomposites of conjugated polymers chemically integrated with quantum dots is studied at high loading levels. The underlying interplay between the exciton transfer and diffusion is revealed.

CF1B • Novel Application of Nonlinear Optics—Continued

CF1B.8 • 09:45

Watt-Level, Tunable, Fiber-Laser-Pumped Picosecond Parametric Source For The Near-Infrared, Suddapalli Chaitanya Kumar[1], Ossi Kimmelma[1], Majid Ebrahim-Zadeh[1,2]; [1]*Nonlinear Optics-Optical Parametric Oscillators, ICFO-The Institute of Photonic Sciences, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We demonstrate a tunable picosecond source providing up to 3.5 W over 752-860 nm, with a power stability of 1.6% rms over 14 hours using intracavity frequency-doubling in optical-parametric-oscillator synchronously pumped by a Yb-fiber laser.

CF1C • EUV Metrology—Continued

CF1C.7 • 09:45

Experimental Validation of a Simple Approximate Relation Between Laser Frequency Noise and Linewidth, Nikola Bucalovic[1], Vladimir Dolgovskiy[1], Christian Schori[1], Pierre Thomann[1], Gianni Di Domenico[1], Stéphane Schilt[1]; [1]*LTF, University of Neuchâtel, Switzerland.* We present an experimental validation of a simple geometrical approximation of the laser linewidth calculated from its frequency noise spectrum, agreeing within the experimental uncertainty with the actual value over a wide range of linewidths.

CLEO: QELS-Fundamental Science

QF1D • Engineered Plasmonic Surfaces—Continued

QF1D.8 • 09:45

Plasmonic Antenna-Array for 2D Sub-Diffraction Focusing Beyond the Optical Near-Field, Yan Wang[1], Amr S. Helmy[1], George V. Eleftheriades[1]; [1]*The Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto, Canada.* We propose an optical probe configuration capable of 2D sub-diffraction imaging at a large working distance at visible frequencies. The structure consists of a planar antenna-array that facilitates super-focusing due to “radiationless interference”.

10:00–10:30 Coffee Break, *Concourse Level*

NOTES

Room A5

CLEO: QELS-Fundamental Science

QF1E • Quantum Optics Using Quantum Dots—Continued

QF1E.8 • 09:45

Planar Waveguide Architecture for the Implementation of a Network of Optically Controlled Quantum Dot Spin Qubits, Isaac J. Luxmoore[1], Nicholas A. Wasley[1], Andrew J. Ramsay[1], Arthur C. Thijssen[2], Ruth Oulton[2], Maxime Hugues[3], Sachin Kasture[4], Achanta V. Gopal[4], Mark Fox[1], Maurice S. Skolnick[1]; [1]*Physics and Astronomy, Univeristy of Sheffield, United Kingdom;* [2]*H.H. Wills Physics Laboratory, University of Bristol, United Kingdom;* [3]*CRHEA-CNRS, France;* [4]*Tata Institute of Fundamental Research, India.* We propose a device architecture for an in-plane network of optically connected quantum dots. Each dot resides at the intersection of two orthogonal waveguides which transmit the full polarization of an emitted photon to another node.

Room A6

CLEO: Science & Innovations

CF1F • Coherent Communications—Continued

Room A7

CLEO: QELS-Fundamental Science

QF1G • Spatial and Temporal Solitons—Continued

QF1G.8 • 09:45

Nonlinear matching of Solitons - Continued redshift between silica and soft-glass fibers, Christian Agger[1], Simon T. Sørensen[1], Carsten L. Thomsen[2], Søren R. Keiding[3], Ole Bang[1]; [1]*DTU Fotonik, Department of Photonics Engineering, Technical University of Denmark, Denmark;* [2]*NKT Photonics, Denmark;* [3]*Department of Chemistry, Aarhus University, Denmark.* We present an analysis of nonlinear coupling between fibers. We introduce the nonlinear coupling coefficient and investigate solitons coupling from one fiber into another. We will also present simulated supercontinuum from concatenated fiber systems.

10:00–10:30 Coffee Break, *Concourse Level*

NOTES

Room C1 & C2 | Room C3 & C4

CLEO: Science & Innovations

CF1J • Photovoltaics Fundamentals and Concepts—Continued

CF1J.5 • 09:45
Angle Selective Transparent-Photovoltaics using Anodized-Alumina, Nanditha Dissanayake[1], Brian Roberts[1], Pei-Cheng Ku[1]; [1]*Electrican Engineering and Computer Science, University of Michigan, USA.* Alumina reflector shows angle selective scattering overcoming transparency vs photocurrent tradeoff in transparent photovoltaics. High scattering is obtained at 45 degree incidence giving high photocurrent maintaining transparency.

CF1K • Short Wavelength Quantum Cascade Lasers—Continued

CF1K.7 • 09:45
Widely Tunable Optically Pumped Mid-IR DFB Laser, Xiang He[1], Steven Benoit[1], S. R. Brueck[1], Ron Kaspi[2]; [1]*CHTM, University of New Mexico, USA;* [2]*Directed Energy Directorate, Air Force Research Laboratory, USA.* A new method has been developed to fabricate chirped grating for type-II optically pumped tunable DFB lasers with a reduced longitudinal variation. Over 80 nm of continuous tuning has been achieved around 3.1 micrometers.

10:00–10:30 Coffee Break, *Concourse Level*

NOTES

Marriott San Jose Salon I & II	Marriott San Jose Salon III	Marriott San Jose Salon IV

CLEO: Science & Innovations

CF1L • High Harmonic and Diffractive Imaging—Continued

CF1L.8 • 09:45

Tabletop Reflection Mode Coherent Diffractive Imaging of Periodic Nano-Structures with 100 nm Resolution, Matthew D. Seaberg[1], Daniel E. Adams[1], Bosheng Zhang[1], Margaret M. Murnane[1], Henry C. Kapteyn[1]; [1]*Physics and JILA, University of Colorado, USA*. We report the first reflection-mode coherent diffraction imaging using a tabletop short wavelength light source. A novel imaging scheme can probe metalic nano-pillar arrays with ~100 nm resolution.

CF1M • Photonic Crystals I—Continued

CF1M.7 • 09:45

Increased Detectivity and Operation Temperature in Photonic Crystal Slab Quantum Well Photodetectors, Stefan Kalchmair[1], Roman Gansch[1], Elvis Mujagic[1], Sang Il Ahn[1], Peter Reininger[1], Gregor Lasser[2], Aaron Maxwell Andrews[1], Hermann Detz[1], Tobias Zederbauer[1], Werner Schrenk[1], Gottfried Strasser[1]; [1]*Institute for Solid State Electronics, Vienna University of Technology, Austria;* [2]*Institute of Telecommunications, Vienna University of Technology, Austria.* Detectivity enhancement up to 20 times is achieved by fabricating a quantum well infrared photodetector as a photonic crystal slab. This enhancement is the combined effect of increased responsivity and noise current reduction.

CF1N • Ultrafast Fiber Lasers—Continued

CF1N.7 • 09:45

High Peak Power Pulse Generation Using Mach-Zehnder-Modulator-Based Flat Comb Generator Combined with Chirped Pulse Amplifier, Isao Morohashi[1], Masahiro Oikawa[2], Yasuaki Tamura[2], Shusei Aoki[2], Takahide Sakamoto[1], Tetsuya Kawanishi[1], Iwao Hosako[1]; [1]*National Institute of Information and Communicatinos Technology, Japan;* [2]*Optohub Co., Ltd., Japan.* We demonstrated generation of ultrashort optical pulses with a peak power of 2.5 kW by combining a Mach-Zehnder-modulator-based flat comb generator with a chirped pulse amplifier.

10:00–10:30 Coffee Break, *Concourse Level*

NOTES

Room A1 | Room A2 | Room A3 | Room A4

CLEO: Science & Innovations

10:30–12:30
CF2A • Light Trapping & Resonators
Zetian Mi, McGill University, Canada, *Presider*

CF2A.1 • 10:30 Invited
Trapping the Light Fantastic, Diederik Wiersma[1], Kevin Vynck[1], Matteo Burresi[1], Francesco Riboli[1]; [1]*European Lab for Nonlinear Spectroscopy (LENS), University of Florence, and CNR-INO Complex Photonics Group, Italy.* We will discuss the possibilities offered by disorder in photonics to create extremely efficient, and simple to realize, traps for light waves for solar energy applications and innovative lighting.

CF2A.2 • 11:00
Rainbow-colored photonic bandgap structure fabricated by holographic lithography, Ke Liu[1], Huina Xu[1], Haifeng Hu[1], Qiaoqiang Gan[1], Alexander Cartwright[1]; [1]*Electrical Engineering, University at Buffalo, The State University at New York, USA.* We report a holographic photopolymerization technique to fabricate a polymeric photonic bandgap structure whose period varies gradually along the length of the structure, leading to a unique rainbow-colored reflection image in the same viewing angle.

CF2A.3 • 11:15
Chalcogenide Glass Photonics: Non-volatile, Bi-directional, All-optical Switching in Phase-change Metamaterials, Behrad Gholipour[1], Jianfa Zhang[1], Feras Al-Saab[1], Kevin F. MacDonald[1], Brian E. Hayden[2], Dan W. Hewak[1], Nikolay I. Zheludev[1]; [1]*Optoelectronics Research Centre, University of Southampton, United Kingdom;* [2]*School of Chemistry, University of Southampton, United Kingdom.* Non-volatile, bi-directional, all-optical switching in a phase-change metamaterial delivers high-contrast transmission and reflection modulation at visible and infrared wavelengths in device structures only ~1/8 of a wavelength thick.

10:30–12:30
CF2B • Optical Parametric Oscillators
Valdas Pasiskevicius, KTH, Sweden, *Presider*

CF2B.1 • 10:30
Interferometrically Output-Coupled Continuous-Wave Optical Parametric Oscillator, Kavita Devi[1], Suddapalli Chaitanya Kumar[1], Adolfo Esteban-Martin[1], Majid Ebrahim-Zadeh[1,2]; [1]*ICFO-Institut de Ciencies Fotoniques, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We demonstrate successful use of antiresonant ring interferometer for optimum output coupling in a continuous-wave singly-resonant OPO, providing 2.28 W of signal, together with 2.95 W of idler, for 23.2 W of pump power.

CF2B.2 • 10:45
Fiber laser pumped, microsecond, single frequency, nested cavities OPO for spectroscopy in the 3.0 - 3.5 µm range, Jessica Barrientos-Barria[1], Jean-Baptiste Dherbecourt[1], Myriam Raybaut[1], Jean-Michel Melkonian[1], Antoine Godard[1], Michel Lefebvre[1]; [1]*ONERA, France.* We report a mid-infrared optical source based on a microsecond, fiber laser pumped, nested cavities, optical parametric oscillator. Power, frequency tuning, frequency purity are studied and compared to the specifications for spectroscopy.

CF2B.3 • 11:00
Dual-Wavelength, Interferometrically Coupled Continuous-Wave Optical Parametric Oscillators, Kavita Devi[1], Venkata Ramaiah-Badarla[1], Suddapalli Chaitanya Kumar[1], Adolfo Esteban-Martin[1], Majid Ebrahim-Zadeh[1,2]; [1]*ICFO-Institut de Ciencies Fotoniques, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report a novel architecture for cw OPOs based on antiresonant ring interferometric cavity coupling, providing two pairs of signal/idler waves with independent tuning and arbitrarily close wavelength separation.

CF2B.4 • 11:15
Milli-joule level 2µm vortex pulses from an optical vortex pumped optical parametric oscillator, Taximaiti Yusufu[1], Yu Tokizane[1,2], Sachio Miyagi[1], Masaki Yamada[1], Katsuhiko Miyamoto[1], Takashige Omatsu[1,2]; [1]*Chiba University, Japan;* [2]*CREST, Japan.* We demonstrate high energy 2 µm optical vortex pulse production from an optical vortex pumped hemispherical optical parametric oscillator. Maximum 2 µm optical vortex pulse energy of 2.1 mJ was achieved.

10:30–12:30
CF2C • Optical Combs and Spectroscopic Applications
Chad Hoyt, Bethel University, USA, *Presider*

CF2C.1 • 10:30
Frequency Comb Synthesizer Tunable from 3 to 10 µm, Axel Ruehl[1], Alessio Gambetta[2], Ingmar Hartl[3], Martin E. Fermann[3], Kjeld Eikema[1], Marco Marangoni[2]; [1]*Vrije Universiteit Amsterdam, Netherlands;* [2]*Politecnico di Milano, Italy;* [3]*IMRA America Inc., USA.* We demonstrate a mid-infrared frequency comb of unprecedented tunability covering the entire 3-10 µm fingerprint region. The comb is based on a Raman shifted Yb:fiber laser and difference frequency generation.

CF2C.2 • 10:45
Broadband Intracavity Molecular Spectroscopy with a Degenerate Mid-IR OPO, Magnus W. Haakestad[2,1], Nick C. Leindecker[2], Alireza Marandi[2], Jie Jiang[3], Ingmar Hartl[3], Martin E. Fermann[3], Konstantin Vodopyanov[2]; [1]*FFI (Norwegian Defence Research Establishment), Norway;* [2]*E.L. Ginzton Laboratory, Stanford University, USA;* [3]*IMRA America, Inc., USA.* Spectroscopic detection of water, isotopic CO2, and methane is performed inside the cavity of a degenerate OPO pumped by an ultrafast Er- or Tm-fiber laser, in the corresponding spectral ranges of 2.7-3.7 and 3.1-5.8 µm.

CF2C.3 • 11:00 Invited
New determination of the fine structure constant and test of the quantum electrodynamics, Rym Bouchendira[1], Pierre Cladé[1], Saïda Guellati-Khélifa[1], François Nez[1], François Biraben[1]; [1]*Laboratoire Kastler Brossel, France.* We report a new value of the fine structure constant with a relative uncertainty of 6.6×10−10. This result is deduced from the h/m ratio measurement on Rb atoms.

CLEO: QELS-Fundamental Science

10:30–12:30
QF2D • Plasmonic Gratings and Photonic Crystals
Martin Husnik, Karlsruhe Institute of Technology, Germany, *Presider*

QF2D.1 • 10:30
Light Transmission Through Circular Metallic Grating Under Broadband Radial and Azimuthal Polarizations Illumination, Gilad Lerman[1], Meir Grajower[1], Avner Yanai[1], Uriel Levy[1]; [1]*Applied physics, Hebrew university of Jerusalem, Israel.* We study light transmission through circular metallic grating under radial/azimuthal polarization illumination and observe strong polarization selectivity and a resonance behavior making it attractive for applications relying on radial polarization.

QF2D.2 • 10:45
2D metallic photonic quasicrystals, Christina Bauer[1], Georg Kobiela[1], Harald Giessen[1]; [1]*4th Physics Institute, University of Stuttgart, Germany.* We present experiments as well as theoretical modelling for 2D metallic photonic quasicrystals. We measured the angle- and polarization-dependent optical properties, confirming our model based on spatial Fourier-transformation and dispersion.

QF2D.3 • 11:00
Multiply Resonant Photonic Crystal Cavities for Nonlinear Frequency Conversion, Sonia Buckley[1], Jelena Vuckovic[1], Kelley Rivoire[1]; [1]*Center for Nanoscale Science and Technology, Stanford University, USA.* We describe a photonic crystal nanocavity with multiple spatially overlapping resonances. We show characterization of structures with two resonances nearly degenerate in frequency and demonstrate structures with resonances separated by up to 592 nm.

QF2D.4 • 11:15
Strong coupling between single quantum dot and localized mode in photonic crystal waveguide, Jie Gao[1], Sylvain Combrié[2], Baolai L. Liang[3], Gaelle Lehoucq[2], Diana L. Huffaker[3], Alfredo De Rossi[2], Chee Wei Wong[1]; [1]*Columbia University, USA;* [2]*Thales Research and Technology, France;* [3]*University of California at Los Angeles, USA.* Strong coupling between single QD and PhC localized mode is observed and theoretical modeling is performed. The results show the great potential of slow-light waveguide for enhanced light-matter interaction and quantum information processing.

Room A5 | Room A6 | Room A7

CLEO: QELS-Fundamental Science

10:30–12:30
QF2E • Cold Atom
Jakob Reichel, Laboratore Kastler Brossel, France, *Presider*

QF2E.1 • 10:30
Optical collisions in a metastable neon MOT, Rohan Glover[1], James Clavert[1], Dane E. Laban[1], Robert T. Sang[1]; [1]*Centre for Quantum Dynamics, Griffith University, Australia.* We present results for controlled optical collisions of cold neon atoms in the (3s)3P2 metastable state trapped in a magneto-optical trap (MOT).

QF2E.2 • 10:45
Spin-squeezing of a large-spin system via QND measurement, Robert J. Sewell[1], Marco Koschorreck[1,2], Mario Napolitano[1], Brice Dubost[1,3], Naeimeh Behbood[1], Morgan W. Mitchell[1]; [1]*ICFO - Institut de Ciències Fotòniques, Spain;* [2]*Physics, University of Cambridge, United Kingdom;* [3]*Laboratoire Mate riaux et Phe nomenes Quantiques, Universite Paris Diderot et CNRS, France.* We demonstrate spin squeezing and entanglement in a large-spin system. We make projection-noise-limited QND measurements of laser-cooled rubidium atoms in the f=1 groundstate, generating −2.6dB of metrologically-relevant squeezing.

QF2E.3 • 11:00
Highly stable remote clock comparisons via 920 km optical fiber for precision spectroscopy of atomic hydrogen, Katharina Predehl[1], Christian G. Parthey[1], Arthur Matveev[1], Axel Beyer[1], Stefan Droste[1], Janis Alnis[1], Nikolai Kolachevsky[1], Randolf Pohl[1], Ronald Holzwarth[1], Thomas Udem[1], Theodor Hänsch[1], Harald Schnatz[2], Gesine Grosche[2], Burghard Lipphardt[2], Stefan Weyers[2]; [1]*Max-Planck-Institute of Quantum Optics, Germany;* [2]*PTB, Germany.* We reference high-precision spectroscopy on atomic hydrogen measured with an uncertainty of 4×10-15 to a remote Cs-fountain clock using a 920 km actively noise-compensated fiber link.

QF2E.4 • 11:15
Atom Interferometry via Raman Chirped Adiabatic Passage, Krish Kotru[1,2], David L. Butts[1,2], Joseph M. Kinast[1], David M. Johnson[1], Brian P. Timmons[1], Antonije M. Radojevic[1], Richard E. Stoner[1]; [1]*The C. S. Draper Laboratory, Inc., USA;* [2]*Aeronautics and Astronautics, Massachusetts Institute of Technology, USA.* Practical atom interferometric sensors may benefit from robust atom optics based on Raman chirped adiabatic passage (RCAP). We demonstrate coherent transfer and interference using RCAP, and discuss expected enhancement of interferometer stability.

10:30–12:30
QF2F • Integrated Quantum Devices
Andrew White, University of Queensland, Australia, *Presider*

QF2F.1 • 10:30
A Reconfigurable Photonic Chip for Generating, Manipulating and Measuring Entanglement and Mixture, Peter Shadbolt[1], Maria Rodas Verde[1], Alberto Peruzzo[1], Alberto Politi[1], Anthony Laing[1], Mirko Lobino[1], Jonathan Matthews[1], Mark G. Thompson[1], Jeremy L. O'Brien[1]; [1]*CQP, University of Bristol, United Kingdom.* We demonstrate a reconfigurable quantum photonic circuit with eight phase shifters. We use this device to generate and characterise maximally entangled two-qubit states, violate Bell inequalities, and generate single-photon mixed states.

QF2F.2 • 10:45
Monolithically-integrated polarization-entangled photon pair source on a silicon-on-insulator photonic circuit, Hanna Le Jeannic[1,2], Nobuyuki Matsuda[1], Hiroki Takesue[1], Hiroshi Fukuda[3], Tai Tsuchizawa[3], Toshifumi Watanabe[3], Koji Yamada[3], Sei-ichi Itabashi[3], Yasuhiro Tokura[1]; [1]*NTT Basic Research Laboratories, Japan;* [2]*ESPCI ParisTech, France;* [3]*NTT Microsystem Integration Laboratories, Japan.* We present a polarization-entangled photon pair source fully integrated on a silicon photonic circuit. Using two silicon wire waveguides connected with a silicon polarization rotator, we demonstrate a generation of polarization-entangled photons.

QF2F.3 • 11:00
Observation of Anderson co-localization of spatially entangled photon pairs, Armando Perez-Leija[1], Giovanni Di Giuseppe[1], Lane Martin[1], Robert Keil[2], Alexander Szameit[2], Ayman F. Abouraddy[1], Demetrios N. Christodoulides[1], Bahaa E.A. Saleh[1]; [1]*The college of Optics and Photonics, CREOL, USA;* [2]*Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Germany.* We report the first observation of Anderson co-localization of spatially entangled photon pairs propagating through random optical waveguide lattices with controllable off-diagonal disorder.

QF2F.4 • 11:15
Generating polarization entangled photons on-chip using concurrent type-I and type-0 processes, Dongpeng Kang[1], Amr S. Helmy[1]; [1]*University of Toronto, Canada.* A novel technique to generate polarization entangled photons using concurrent type-I and type-0 processes in a monolithic chip is discussed. Perfect entanglement is achievable through appropriate epi-structure design.

10:30–12:30
QF2G • Nonlinear Optical Processes
Lucia Caspani, INRS-EMT, Canada, *Presider*

QF2G.1 • 10:30
Two-dimensional infrared imaging by frequency upconversion at few-photon level, Kun Huang[1], Xiaorong Gu[1], Haifeng Pan[1], E. Wu[1], Heping Zeng[1]; [1]*State Key Laboratory of Precision Spectroscopy, East China Normal University, China.* We demonstrated few-photon-level infrared imaging at 1040 nm by coincidence frequency upconversion with a high conversion efficiency of 31%. The full imaging was implemented without any scanning devices, thus gaining in simplicity and speed.

QF2G.2 • 10:45
Phase conjugation based on backward difference-frequency generation: a novel scheme, Yujie J. Ding[1]; [1]*Electrical & Computer Engineering, Lehigh University, USA.* We show that backward difference-frequency generation can be exploited to achieve phase conjugation in a second-order nonlinear medium. Our calculation shows that a reflectivity of close to 100% is achievable from a 1 mW laser.

QF2G.3 • 11:00
Optimization of the 3D non-paraxial illumination volume for multiphoton florescence microscopy, Jonathan Nemirovsky[1], Ido Kaminer[1], Mordechai Segev[1]; [1]*Physics Department, Technion, Israel.* We present a new approach for optimizing a 3D non-paraxial volume for multiphoton florescence microscopy. Our optimized solutions demonstrate volume reduction of up to 6.5, compared to the best current design for three-photon microscopy.

QF2G.4 • 11:15
Single Shot Two Dimensional Spectroscopy of Photo-bleachable Molecules, Andrey Shalit[1], Iddo Pinkas[2], Alexander Brandis[3], Yehiam Prior[1]; [1]*Chemical Physics Department, Weizmann Institute of Science, Israel;* [2]*Department of Chemical Research Support, Weizmann Institute of Science, Israel;* [3]*Department of Plant Sciences, Weizmann Institute of Science, Israel.* Vibrational spectra of highly photo-bleachable molecules are measured, and ground- and excited-state dynamics is observed by single shot four wave mixing enabled using a novel geometrical mapping of the delay times in the beams.

Room A8 — CLEO: QELS-Fundamental Science

Room B2 & B3 / **Room C1 & C2** / **Room C3 & C4** — CLEO: Science & Innovations

10:30–12:30
QF2H • Periodic Materials Phenomena
Meir Orenstein, Technion Israel Institute of Technology, Israel, *Presider*

QF2H.1 • 10:30 Invited
Strain-induced Band Gap and Effective Magnetic Field in Photonic Crystals, Mikael C. Rechtsman[1], Alexander Szameit[2], Mordechai Segev[1]; *[1]Solid State Institute, Technion - Israel Institute of Technology, Israel; [2]Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Germany.* We show that a certain inhomogeneous strain induces an effective magnetic field in photonic crystals that have Dirac points. The magnetic field induces highly degenerate Landau levels and band gaps in between them.

QF2H.2 • 11:00
Near-field observations of self-collimation in photonic crystal superlattices, Pin-Chun Hsieh[1], Chung-Jen Chung[2], Serdar Kocaman[1], Claudiu Biris[3], Ming Lu[4], Nicolae Panoiu[3], Chee Wei Wong[1]; *[1]Mechanical Engineering, Columbia University, USA; [2]Center for Micro/Nano Science and Technology, National Chen Kung University, Taiwan; [3]Photonics Group, Department of Electronic and Electrical Engineering, University College London, United Kingdom; [4]Center for Functional Nanomaterials, Brookhaven National Laboratory, USA.* We present experimental observations of self-collimation effect in photonic crystal superlattices consisting of photonics crystal region and homogeneous media.

QF2H.3 • 11:15
Fundamental limitations to gain enhancement in slow-light photonic structures, Jure Grgic[1], Johan Raunkjær Ott[1], Fengwen Wang[2], Ole Sigmund[2], Antti-Pekka Jauho[3], Jesper Mørk[1], N. Asger Mortensen[1]; *[1]Department of Photonics Engineering, DTU Fotonik, Denmark; [2]Department of Mechanical Engineering, Solid Mechanics, DTU Mekanik, Denmark; [3]Department of Micro- and Nanotechnology, DTU Nanotech, Denmark.* We present a non-perturbative analysis of light-matter interaction in active photonic crystal waveguides in the slow-light regime. Inclusion of gain is shown to modify the underlying dispersion law, thereby degrading the slow-light enhancement.

10:30–12:15
CF2I • Optical Signal Processing
Michael Dennis, Johns Hopkins University, USA, *Presider*

CF2I.1 • 10:30
Wavelength Shifting of a 21.4-Gbaud 16-QAM Signal using Highly Nonlinear Silica Fiber, R. M. Jopson[1], A. H. Gnauck[1], Evgeny Myslivets[2], Bill P.P. Kuo[2], M. Dinu[2], P. J. Winzer[1], Nikola Alic[2], Stojan Radic[2]; *[1]Bell Labs, Alcatel-Lucent, USA; [2]UCSD, USA.* Longitudinal stress reduces the stimulated-Brillouin-scattering threshold in a silica-fiber parametric amplifier, allowing ditherless pumping. This enables phase conjugation of a 21.4-Gbaud 16-QAM signal with less than 0.6-dB penalty.

CF2I.2 • 10:45
Spread-Spectrum Chromatic Dispersion Monitoring Technique for Flexible Bandwidth Channels, Xinran R. Cai[1], David J. Geisler[1], Roberto Proietti[1], Yawei Yin[1], Ryan P. Scott[1], S. J. Ben Yoo[1]; *[1]Dept. of Electrical and Computer Engineering, UC Davis, USA.* We exploit an in-band, 50-MHz supervisory channel for chromatic dispersion monitoring of variable-bandwidth flexpaths. Results show monitoring optimization tradeoffs and dispersion measurements for a 400-GHz flexpath with up to 100-km link lengths.

CF2I.3 • 11:00
All-Optical Switching for Dynamic Wavelength Routing of 100G Pol-Mux QPSK data, Claudio Porzi[1], Gianluca Meloni[1], Marco Secondini[1], Luca Potì[2], Giampiero Contestabile[1], Antonella Bogoni[2]; *[1]Scuola Superiore Sant'Anna, Italy; [2]CNIT, Italy.* Simultaneous wavelength conversion and channel drop operation for 112 Gb/s polarization-multiplexed QPSK signals is demonstrated by using a single SOA-MZI controlled by an optical gate signal. After coherent detection, low OSNR penalty is measured.

CF2I.4 • 11:15
Tunable Complex-Weight All-Optical IIR Filter Design based on Conversion/Dispersion Delays, Mohammad Reza Chitgarha[1], Salman Khaleghi[1], Omer F. Yilmaz[1], Moshe Tur[2], Michael W. Haney[3], Alan Willner[1]; *[1]University of Southern California, USA; [2]Tel Aviv University, Israel; [3]University of Delaware, USA.* We propose and study the design of a tunable optical infinite-impulse-response filter based on conversion/dispersion delays. Design guidelines are presented to alleviate the effects of the inherent system propagation delay.

10:30–12:30
CF2J • Next-Generation Photovoltaics I
Meredith Reed, US Army Research Laboratory, USA, *Presider*

CF2J.1 • 10:30
The Opto-Electronics which Broke the Efficiency Record in Solar Cells, Eli Yablonovitch[1,2], Owen D. Miller[1,2]; *[1]Material Sciences Division, Lawrence Berkeley National Laboratory, USA; [2]Electrical Engineering & Comp. Sciences Dept., University of California, Berkeley, USA.* As solar cells exceed 25% efficiency, photon management becomes far more important than electronic properties. Surprisingly, maximizing external fluorescence increases efficiency, the key behind the recent single-junction efficiency record of 28.4%.

CF2J.2 • 10:45
Inverse Design of a Nano-Scale Surface Texture for Light Trapping, Owen D. Miller[1,2], Vidya Ganapati[1,2], Eli Yablonovitch[1,2]; *[1]Material Sciences Division, Lawrence Berkeley National Laboratory, USA; [2]Electrical Engineering & Comp. Sciences Dept., University of California, Berkeley, USA.* We introduce computational inverse design to optimize nano-scale surface textures for light trapping. The approach yields a structure with a 40.8 absorption enhancement factor, the highest reported for a high-index material in the full-wave domain.

CF2J.3 • 11:00
Effect of aperiodicity on the broadband reflection of silicon nanorod structures for photovoltaics, Chenxi Lin[1], Ningfeng Huang[1], Michelle L. Povinelli[1]; *[1]University of Southern California, USA.* We study the effect of aperiodicity on silicon nanorod anti-reflection structures. Numerical results reveal that randomness is beneficial for small nanorod sizes. A guided random walk algorithm is used to obtain optimized aperiodic structures.

CF2J.4 • 11:15
Limiting Efficiencies of Tandem Solar Cells for III-V Nanowire Arrays on Silicon Substrates, Ningfeng Huang[1,2], Chenxi Lin[1,2], Michelle L. Povinelli[1,2]; *[1]Ming Hsieh Department of Electrical Engineering, University of Southern California, USA; [2]Center for Energy Nanoscience, University of Southern California, USA.* We use electromagnetic simulations and detailed balance analysis to calculate limiting efficiencies of tandem solar cells consisting of III-V nanowires on silicon. We optimize the nanowire structural parameters and provide general design guidelines.

10:30–12:30
CF2K • Quantum Cascade Laser Design & Characterization
Claire Gmachl, Princeton, USA, *Presider*

CF2K.1 • 10:30
Comparison Study of the Influence of Taller Electron Exit Barriers on the Device Performance for Ultra-strong Coupling Quantum Cascade Laser Designs, Peter Q. Liu[1], Pierre Bouzi[1], Yamac Dikmelik[1,2], Nyan L. Aung[1], Xiaojun Wang[3], Jen-Yu Fan[3], Claire Gmachl[1]; *[1]Princeton University, USA; [2]Department of Electrical and Computer Engineering, Johns Hopkins University, USA; [3]AdTech Optics, USA.* Two different ultra-strong coupling Quantum Cascade laser designs and their modified versions with two taller electron exit barriers are compared experimentally to study the influence of such taller electron exit barriers on the device performance.

CF2K.2 • 10:45
Novel injector schemes for Mid-Infrared-Quantum-Cascade-lasers, toward the genetic optimization of the laser design, Alfredo Bismuto[1]; *[1]Physics, ETHZ, Switzerland.* Using a novel transport model based on density matrix, a new injector design for Mid-IR quantum-cascade-lasers is presented that improves laser performance. Results on automatized optimization of laser design using genetic algorithms are also shown.

CF2K.3 • 11:00
Tapered Active-Region Quantum Cascade Lasers for Virtual Suppression of Carrier-Leakage Currents, Jeremy D. Kirch[1], Chun-Chieh Chang[1], Jae C. Shin[1], Luke J. Mawst[1], Dan Botez[1], Tom Earles[2]; *[1]ECE, University of Wisconsin-Madison, USA; [2]Intraband, LLC, USA.* A quantum-cascade laser design for effectively suppressing carrier leakage is demonstrated. The characteristic temperatures for threshold and slope efficiency, T0 and T1, reach values of 231 K and 797 K over the 20-60oC range

CF2K.4 • 11:15
Time-resolved spectral characterization of a pulsed external-cavity quantum cascade laser, Jean-Michel Melkonian[1], Johan Petit[1], Myriam Raybaut[1], Antoine Godard[1], Michel Lefebvre[1]; *[1]Onera, France.* The time-resolved spectrum of a pulsed external-cavity QCL is obtained thanks to sum-frequency mixing with nanosecond pump pulses with a variable delay. Frequency chirps and mode hops spanning over 30 GHz are observed.

CLEO: Science & Innovations

Marriott San Jose Salon I & II

10:30–12:00
CF2L • Ultrafast Devices
Presider TBD

CF2L.1 • 10:30
Ultrafast switching of hard X-rays, Peter Gaal[1], André Bojahr[1], Marc Herzog[1], Yevgen Goldshteyn[2], Roman Shayduk[2], Wolfram Leitenberger[1], Hengameh Navirian[2], Dimitry Khakhulin[3], Michael Wulff[3], Matias Bargheer[1,2]; *[1]Institute for Physics and Astronomy, University of Potsdam, Germany; [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Germany; [3]European Synchrotron Radiation Facility (ESRF), France.* A 100 ps synchrotron pulse of hard X-rays is shorted to few picoseconds by exploiting coherent phonon dynamics in a thin metallic SrRuO3 layer. A first pump-probe experiment with the shortened X-ray pulse is presented.

CF2L.2 • 10:45
Optical Cross Correlator in a Silicon Waveguide, Moti Fridman[1], Yoshitomo Okawachi[1], Stephane Clemmen[1], Michael Menard[2], Michal Lipson[2,3], Alexander Gaeta[1,3]; *[1]applied physics, Cornell university, USA; [2]School of Electrical and Computer Engineering, Cornell University, USA; [3]Kavli Institute at Cornell for Nanoscale Science, Cornell University, USA.* We present a technique for performing single-shot optical cross-correlations in a silicon waveguide and show that it can be applied to the cross correlation of two 300-fs signals.

CF2L.3 • 11:00
25-Gbps Operation of Silicon p-i-n Mach-Zehnder Optical Modulator with 100-µm-Long Phase Shifter, Takeshi Baba[1,3], Suguru Akiyama[1,3], Masahiko Imai[1,3], Takeshi Akagawa[1,3], Masashi Takahashi[2,3], Naoki Hirayama[2,3], Hiroyuki Takahashi[1,3], Yoshiji Noguchi[2,3], Hideaki Okayama[1,3], Tsuyoshi Horikawa[2,3], Tatsuya Usuki[1,3]; *[1]Photonics Electronics Technology Research Association, Japan; [2]National Institute of Advanced Industrial Science and Technology, Japan; [3]Institute for Photonics-Electronics Convergence System Technology, Japan.* We developed a high-speed Mach-Zehnder modulator with the shortest phase shifter (100-µm length) reported so far. Our modulator exhibited 25-Gbps eye-openings with an extinction ratio of 4.3 dB and on-chip insertion loss of 4.7 dB.

CF2L.4 • 11:15
25-Terahertz-Bandwidth Optical Temporal Differentiator Based on a Wavelength-Selective Directional Coupler, Ming Li[1], Hoe-Seok Jeong[2], Tae-Jung Ahn[2], José Azana[1]; *[1]INRS-EMT, Canada; [2]Chosun University, Republic of Korea.* An optical temporal differentiator with a record operation bandwidth of ~25 THz is demonstrated based on a wavelength-selective directional coupler. An optical Gaussian pulse with a bandwidth of ~500 GHz is successfully differentiated.

Marriott San Jose Salon III

10:30–12:30
CF2M • Plasmonics and Light-Matter Interactions
Vasily Astratov, University of North Carolina at Charlotte, USA, *Presider*

CF2M.1 • 10:30
Plasmonic Photoconductive Terahertz Emitters Based on Nanoscale Gratings, Christopher W. Berry[1], Mona Jarrahi[1]; *[1]Electrical Engineering and Computer Science, University of Michigan, USA.* A photoconductive terahertz emitter based on a long-carrier lifetime semiconductor is demonstrated experimentally. Plasmonic grating electrodes enable ultrafast, high quantum efficiency operation, without need for a short-carrier lifetime substrate.

CF2M.2 • 10:45
Direct SNOM of quadrupolar plasmon mode selectively excited on gold nanowire in PCF, Patrick S. Uebel[1], Markus A. Schmidt[1], Howard W. Lee[1], Philip S. Russell[1]; *[1]Russell Division, Max Planck Institute for the Science of Light, Germany.* The near-field profile of a quadrupolar plasmon mode, guided on a gold nanowire incorporated in a PCF, is imaged using SNOM. The mode is excited by phase-matched coupling from an adjacent glass core.

CF2M.3 • 11:00
Leak-free Focusing of Propagating Surface Plasmon Waves Using Non-symmetric Double Nanorings, Beibei Zeng[1], Yongkang Gao[1], Filbert J. Bartoli[1]; *[1]Electrical and Computer Engineering Department, Lehigh University, USA.* Leak-free focusing is proposed using nonsymmtric double nanorings. A single focal spot could be obtained at the geometric center through the constructive interference of two anti-propagating SP waves by breaking the geometrical symmetry.

CF2M.4 • 11:15
New Electro-Optic Switch Using Symmetric Five-Layer Plasmonic Waveguide with Light-Coupling Slot-Antennas, Josuke Ozaki[1], Hiroshi Murata[1], Junichi Takahara[2], Yasuyuki Okamura[1]; *[1]Systems Innovation, Graduate School of Engineering Science, Osaka University, Japan; [2]Applied Physics, Graduate School of Engineering, Osaka University, Japan.* New electro-optic switches composed of Au/LiNbO3 coupled structures with slot-antenna arrays are proposed. Utilizing selective coupling to the SPP even mode by antennas and its control by electro-optic effects, new plasmonic switches are obtainable.

Marriott San Jose Salon IV

10:30–12:30
CF2N • High Power Fiber Lasers and Beam Combining
John Minelly, Coherent Inc., USA, *Presider*

CF2N.1 • 10:30
Phase-Locking and Coherent Power Combining of Linearly Chirped Optical Waves, Naresh Satyan[1], Arseny Vasilyev[1], George Rakuljic[2], Jeffrey O. White[3], Amnon Yariv[1]; *[1]Department of Applied Physics and Materials Science, California Institute of Technology, USA; [2]Telaris Inc., USA; [3]Army Research Laboratory, USA.* Rapidly chirped optical waves reduce SBS in fiber amplifiers, enabling higher output powers. This work demonstrates homodyne and heterodyne phase-locking, and coherent combining, of linearly chirped optical waves using acoustooptic frequency shifters.

CF2N.2 • 10:45
Coherent Beam Combination of Fiber Laser Arrays via Multiplexed Volume Bragg Gratings, Chunte A. Lu[1], Angel Flores[1], Erik Bochove[1], William Roach[1], Vadim Smirnov[2], Leonid Glebov[3,2]; *[1]Air Force Research Laboratory, USA; [2]OptiGrate Corp, USA; [3]CREOL/UCF, USA.* We report the first experimental demonstration of active coherently combining of fiber laser arrays with multiplexed volume Bragg gratings up to 70W combined output power with diffraction limited beam quality achieved at 82% combining efficiency.

CF2N.3 • 11:00
Clad-Pumped YDFLs Operating in the 1150-1200 nm Range, Vladislav V. Dvoyrin[1], Oleg I. Medvedkov[2], Irina T. Sorokina[1]; *[1]Department of Physics Faculty of Natural Sciences and Technology Norwegian University of Science and Technology (NTNU), Norway; [2]Fiber Optics Research Center, Russian Academy of Sciences, Russian Federation.* We demonstrate clad-pumped YDFLs operating at the 1147, 1160 and 1180 nm wavelengths at 35, 21 and 10.5 W of output power, respectively; operation at 1200 nm was realized for the first time.

CF2N.4 • 11:15
External-Cavity Cr^{4+}:YAG Double-Clad Crystal Fiber Laser, Dong-Yo Jheng[1], Chien-Chih Lai[1], Kuang-Yu Hsu[1], Yen-Sheng Lin[1], Ying-Jie Chen[1], Sheng-Lung Huang[1,2]; *[1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taiwan; [2]Department of Electrical Engineering, National Taiwan University, Taiwan.* An external-cavity and laser-diode-pumped Cr4+:YAG double-clad crystal fiber laser was demonstrated with a threshold pump power of 69 mW. It was polarized with a 30:1 extinction ratio, and no any polarization-controlled element was used.

Room A1 | Room A2 | Room A3 | Room A4

CLEO: Science & Innovations

CLEO: QELS-Fundamental Science

CF2A • Light Trapping & Resonators—Continued

CF2A.4 • 11:30
Design and Fabrication of Helical Structures via Proximity-field Nano-Patterning (PnP) for Application as Chiral Metamaterials, Sidhartha Gupta[1], James W. Rinne[1], Thomas C. Galvin[2], Kevin A. Arpin[1], Daniel Dregely[3], Harald W. Giessen[3], J. G. Eden[2], Pierre Wiltzius[4], Paul V. Braun[1]; [1]*Department of Materials Science & Engineering, University of Illinois at Urbana-Champaign, USA;* [2]*Department of Electrical & Computer Engineering, University of Illinois at Urbana-Champaign, USA;* [3]*4. Physikalisches Institut, Universität Stuttgart, Germany;* [4]*University of California Santa Barbara, USA.* We demonstrate the use of a genetic algorithm based inverse design technique to target and fabricate helical structures via PnP. We furthermore show their inversion into other functional materials and their application as chiral metamaterials.

CF2A.5 • 11:45
High quality factor and high confinement silicon resonators using etchless process, Austin G. Griffith[1], Jaime Cardenas[1], Carl B. Poitras[1], Michal Lipson[1]; [1]*Cornell University, USA.* We demonstrate high-Q factor and high confinement silicon ring resonators fabricated by a local oxidation of silicon (LOCOS) process. We achieve an intrinsic quality factor of 525,000 in 410 µ m-circumference ring resonator.

CF2A.6 • 12:00
Frequency Locked Micro Disk Resonator for improved Sensing resolution and overcoming perturbations in NSOM measurements, Liron Stern[1], Ilya Goykhman[1], Boris Desiatov[1], Uriel Levy[1]; [1]*Applied Physics, The Hebrew University of Jerusalem, Israel.* We experimentally demonstrate locking of a laser frequency to a resonance line of a micro disk resonator. Achieving 1±0.1 pm shifting detection, the approach can be applied for sensing enhancement and perturbation immune NSOM measurements.

CF2A.7 • 12:15
Self-referencing Multimode Photonic Microresonator, Yasha Yi[1]; [1]*1N-223, NYU and CUNY, USA.* Here we report that a self referencing mechanism can be achieved by simultaneous excitation of both fundamental and 2nd order micro disk optical resonance modes.

CF2B • Optical Parametric Oscillators—Continued

CF2B.5 • 11:30
Actively Mode-Locked Optical Parametric Oscillator Using Low-Frequency Phase-Modulation, Kavita Devi[1], Suddapalli Chaitanya Kumar[1], Majid Ebrahim-Zadeh[1,2]; [1]*ICFO-Institut de Ciencies Fotoniques, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report active mode-locking of a continuous-wave optical parametric oscillator in doubly- and singly-resonant configuration using direct low-frequency electro-optic phase-modulation, generating 533ps and 230ps pulses at 80MHz, respectively.

CF2B.6 • 11:45
Tolerance and Tuning of Diffraction-Grating Narrowed Synchronously Pumped Optical Parametric Oscillators, Cédric LaPorte[1], Jean-Baptiste Dherbecourt[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Antoine Godard[1]; [1]*ONERA - the French Aerospace Lab, France.* Line-narrowing of a synchronously-pumped OPO using an intracavity diffraction grating leads to a fivefold increase of the resonator-length detuning tolerance. We show that this effect is due to resonant beam geometric adaptation within the cavity.

CF2B.7 • 12:00
Synchronized retro-reflection-pumped femtosecond optical parametric oscillator, Adolfo Esteban-Martin[1], Venkata Ramaiah-Badarla[1], Majid Ebrahim-Zadeh[1,2]; [1]*ICFO-Institut de Ciencies Fotoniques, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We demonstrate a practical technique for pre-oscillation threshold reduction, output power enhancement, and high frequency pulse train engineering in synchronously-pumped optical parametric oscillators based on synchronized retro-reflected pumping.

CF2B.8 • 12:15
Milliwatt-level Mid-infrared Difference Frequency Generation with a Femtosecond Dual-signal-wavelength Optical Parametric Oscillator, Robin Hegenbarth[1], Andy Steinmann[1], György Tóth[2], János Hebling[2], Harald Giessen[1]; [1]*4th Physics Institute and Research Center SCOPE, University of Stuttgart, Germany;* [2]*Department of Experimental Physics, University of Pécs, Hungary.* We report on mid-infrared difference frequency generation with a dual-signal-wavelength femtosecond optical parametric oscillator. We achieved up to 1.2 mW average power at 42 MHz at wavelengths tunable between 11 and 18 µm.

CF2C • Optical Combs and Spectroscopic Applications—Continued

CF2C.4 • 11:30
Spectrally flat, broadband visible-wavelength astro-comb, Guoqing Chang[1], Chih-Hao Li[2], Alexander Glenday[2], Gabor Furesz[2], Nick Langellier[2], Li-Jin Chen[1], Matthew W. Webber[2], Jinkang Lim[1], Hung-Wen Chen[1], David F. Phillips[2], Andrew Szentgyorgyi[2], Ronald L. Walsworth[2], Franz X. Kaertner[1,3]; [1]*EECS, MIT, USA;* [2]*Harvard-Smithsonian Center for Astrophysics, Harvard University, USA;* [3]*Center for Free-Electron Laser Science, DESY and University of Hamburg, Germany.* We demonstrate a broadband visible-wavelength astro-comb enabled by: (1) dispersion-managed FOCR for green-to-red source-comb generation and (2) complementary chirped-mirror pairs for constructing broadband Fabry-Perot filtering cavities.

CF2C.5 • 11:45
Conjugate Fabry-Perot cavity pair for astro-combs, Chih-Hao Li[1], Guoqing Chang[2], Alexander Glenday[1], David F. Phillips[1], Franz X. Kaertner[2,3], Ronald L. Walsworth[1]; [1]*Harvard University, USA;* [2]*Massachusetts Institute of Technology, USA;* [3]*University of Hamburg, Germany.* We propose a new mode-filtering scheme for astro-combs using two Fabry-Perot cavities: a "conjugate Fabry-Perot cavity pair". Simulations suggest that this scheme improves astro-comb accuracy in the presence of errors from nonlinear fibers.

CF2C.6 • 12:00
Coherent dual-comb spectroscopy with frequency combs stabilized by free-running CW lasers, Naoya Kuse[1], Akira Ozawa[1], Yohei Kobayashi[1]; [1]*ISSP, University of Tokyo, Japan.* We demonstrated coherent dual-comb spectroscopy with two Yb-fiber lasers phase-locked to each other by using free-running CW lasers. The relative timing/phase jitter was strongly suppressed, resulting in comb resolution after coherent averaging.

CF2C.7 • 12:15
Accurate Fiber-based Acetylene Frequency References, Chenchen Wang[1], Nathalie V. Wheeler[2], Coralie F. Dutin[2,3], Michael Grogan[2], Tom Bradley[2,3], Brian R. Washburn[1], Fetah Benabid[2,3], Kristan L. Corwin[1]; [1]*Physics, Kansas State University, USA;* [2]*Physics, University of Bath, United Kingdom;* [3]*Xlim Research Institute, Université de Limoges, France.* An all-fiber based acetylene frequency reference is achieved with ~100 kHz accuracy. The three-cornered hat method was used to calibrate the stability of fiber-based frequency, and a 2×10-12 stability at 0.1 s is obtained.

QF2D • Plasmonic Gratings and Photonic Crystals—Continued

QF2D.5 • 11:30
Photonic Crystal Microcavities in Single Crystal Diamond for Color Center Coupling, Janine Riedrich-Möller[1], Laura Kipfstuhl[1], Christian Hepp[1], Sebastien Pezzagna[2], Jan Meijer[2], Martin Fischer[3], Stefan Gsell[3], Matthias Schreck[3], Christoph Becher[1]; [1]*Fachrichtung 7.2 (Experimentalphysik), Universitaet des Saarlandes, Germany;* [2]*RUBION, Ruhr-Universitaet Bochum, Germany;* [3]*Experimentalphysik IV, Universitaet Augsburg, Germany.* We fabricate photonic crystal microcavities in a single crystal diamond membrane and actively tune the cavity modes into resonance with the emission line of color centers in diamond to enhance the emission rate.

QF2D.6 • 11:45
Collimation of Raman scattering with plasmonic structures, Wenqi Zhu[1], Dongxing Wang[1], Yizhuo Chu[1], Kenneth B. Crozier[1]; [1]*Harvard University-SEAS, USA.* We demonstrate the collimation of Raman scattering by a SERS substrate consisting of optical antennas, a metallic reflector and a 1D grating of metal strips. A ~6.1° FWHM angle perpendicular to the strips is measured.

QF2D.7 • 12:00
High-Q, Low Index-Contrast Polymeric Photonic Crystal Nanobeam Cavities, Qimin Quan[1], Ian B. Burgess[1], Sindy Tang[2], Daniel Floyd[1], Marko Loncar[1]; [1]*Harvard, USA;* [2]*Stanford University, USA.* We present the realization of high-Q (Q=36000) polymeric photonic crystal nanobeam cavities made of two polymers that have an ultra-low index contrast, and demonstrate that these polymer cavities are outstanding refractive index sensors (FOM=9190).

QF2D.8 • 12:15
Polarization-independent Fano resonances in one dimensional arrays of core-shell nanospheres, Wei Liu[1], Andrey M. Miroshnichenko[1], Dragomir N. Neshev[1], Yuri S. Kivshar[1]; [1]*Nonlinear Physics Centre and Centre for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), Australian National University, Australia.* We study light scattering by one-dimensional arrays of core-shell nanospheres and reveal the existence of polarization-independent Fano resonances due to the interference of degenerate magneto-electric Mie resonances with Wood's anomaly of the array.

12:30–13:30 Lunch Break *(on your own)*

Room A5 | Room A6 | Room A7

CLEO: QELS-Fundamental Science

QF2E • Cold Atom—Continued

QF2E.5 • 11:30
Large area Sagnac interferometer based on laser-cooled atoms, Gunnar Tackmann[1], Peter Berg[1], Christian Schubert[1], Sven Abend[1], Wolfgang Ertmer[1], Ernst Rasel[1]; [1]*Institut für Quantenoptik, Leibniz Universität Hannover, Germany.* We present a high resolution atom interferometer gyroscope based on stimulated Raman transitions of neutral atoms. Employing three separate interaction zones allows to enlarge the signal while maintaining high compactness.

QF2E.6 • 11:45
Ultra-High Compton Frequency Atomic Interferometric Gyroscope Using Collective States, Selim M. Shahriar[1], Resham Sarkar[1], May Kim[1], Yanfei Tu[1]; [1]*Northwestern University, USA.* We show that a cluster of N atoms can be split and recombined as a single particle, with a Compton frequency higher by a factor of N than a single atom, making a supersensitive gyroscope.

QF2E.7 • 12:00
Measurement of the system-environment coupling and its relation to dynamical decoupling, Nir Davidson[1], Ido Almog[1], Yoav Sagi[1], Goren Gordon[1], Guy Bensky[1], Gershon Kurizki[1]; [1]*Weizmann Institute of Science, Israel.* We present a direct measurement of the bath coupling spectrum in an ensemble of trapped ultracold atoms, by applying a spectrally narrow-band control field. From the inferred spectrum we predict the performance of some dynamical decoupling sequences.

QF2E.8 • 12:15
Anomalous Diffusion and Fractional Self-Similarity of Ultra Cold Atoms in One Dimension, Nir Davidson[1], Yoav Sagi[1], Ido Almog[1], Rami Pugatch[1]; [1]*Weizmann Institute of Science, Israel.* We observe spatial anomalous diffusion of ultra-cold atoms in one-dimensional dissipative optical lattices, and demonstrate its fractional self-similar scaling in both space and time.

QF2F • Integrated Quantum Devices—Continued

QF2F.5 • 11:30
Electrically generated indistinguishable and entangled photon pairs, Jonas Nilsson[1], Mark Stevenson[1], Cameron L. Salter[1,2], Anthony J. Bennett[1], Martin B. Ward[1], Ian Farrer[2], David A. Ritchie[2], Andrew J. Shields[1]; [1]*Toshiba Research Europe Limited, United Kingdom;* [2]*Cavendish Laboratory, University of Cambridge, United Kingdom.* We present measurements on electrically generated photons from a quantum dot in an LED structure, showing high entanglement fidelity and two-photon interference visibility, both necessary requirements for scalable quantum communication and logic.

QF2F.6 • 11:45
Pyramidal Microcavities for Improved Optically and Electrically Driven Single-Photon Sources, Daniel Rülke[1], Daniel M. Schaadt[1,2], Heinz Kalt[1], Michael Hetterich[1]; [1]*Institut für Angewandte Physik and DFG Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology (KIT), Germany;* [2]*Institute for Energy Research and Physical Technologies, Clausthal University of Technology, Germany.* Reversed pyramidal GaAs microcavities with embedded InAs quantum dots have been fabricated, in order to prove their potential for highly efficient single-photon emitters. Contacted via tiny bridges, they have been driven optically and electrically.

QF2F.7 • 12:00
Photons on demand from an electrically driven single quantum dot under pulsed excitation, Matthias Florian[1], Paul Gartner[1], Christopher Gies[1], Frank Jahnke[1], Christian Kessler[2], Fabian Hargart[2], W. Schulz[2], Matthias Reischle[2], Marcus Eichfelder[2], Robert Rossbach[2], Michael Jetter[2], Peter Michler[2]; [1]*Institute for Theoretical Physics, University of Bremen, Germany;* [2]*Institut für Halbleiteroptik und Funktionelle Grenzflächen, University of Stuttgart, Germany.* For a single quantum dot under excitation with short electrical pulses the dependence of the photon anti-bunching on pulse width and excitation strength is studied in a theory-experiment collaboration.

QF2F.8 • 12:15
Continuously adjustable narrow-band heralded single photon source, Michael J. Foertsch[1,2], Josef Fuerst[1,2], Christoffer Wittmann[1,2], Dmitry Strekalov[1,3], Andrea Aiello[1,2], Christine Silberhorn[1], Christoph Marquardt[1,2], Gerd Leuchs[1,2]; [1]*Max Planck Institute for the Science of Light, Germany;* [2]*Institut fuer Optik, Information und Photonik, Germany;* [3]*Jet Propulsion Laboratory, USA.* We present the high efficient generation of narrow-band heralded single photons, widely tunable in wavelength and bandwidth using resonator enhanced spontaneous down conversion in a crystalline whispering gallery mode resonator.

QF2G • Nonlinear Optical Processes—Continued

QF2G.5 • 11:30
Tunable Giant Multi-Photon Absorption using Seeded CdSe/CdS Nanorod Heterostructures, Tze Chien Sum[1], Guichuan Xing[1], Cheng Hon Alfred Huan[1], Sabyasachi Chakrabortty[2], Yin Thai Chan[2]; [1]*Division of Physics and Applied Physics, Nanyang Technological University, Singapore;* [2]*Department of Chemistry, National University of Singapore, Singapore.* A clear strategy to enhance MPA cross-sections whilst independently tuning the emissive wavelengths of semiconductor QDs using seeded CdSe/CdS nanorod heterostructures is presented. Giant σ 2-3 orders larger than QDs were achieved.

QF2G.6 • 11:45
Looking at the Spectra of the Individual Orders Produced in Multi-frequency Raman generation, Donna Strickland[1], Zheng Cui[1], Mayank Chaturvedi[1], Baolin Tian[1], Jason Ackert[1], Fraser Turner[1]; [1]*Physics and Astronomy, University of Waterloo, Canada.* The competition between multi-frequency Raman generation and four-wave mixing is investigated by studying the spectral properties of the high-order, anti-Stokes orders.

QF2G.7 • 12:00
IR detection in wide-gap semiconductors using extreme nondegenerate two-photon absorption, Himansu Pattanaik[1], Dmitry Fishman[1], Scott Webster[1], David Hagan[1], Eric Van Stryland[1]; [1]*CREOL, College of Optics and Photonics, University of Central Florida, USA.* We compare GaAs and GaN for IR detection using extremely non-degenerate two-photon absorption. While the small gap material has larger ND-2PA and hence better sensitivity to IR, unwanted background from degenerate 2PA outweighs this advantage.

QF2G.8 • 12:15
Spectral Mirror Imaging in Ultrafast Optical Parametric Processes, Chenji Gu[1], Boaz Ilan[1], Jay E. Sharping[1]; [1]*Univ. of California, USA.* We experimentally demonstrate and theoretically explore a spectral imaging system where two spectral sidebands produced through an optical parametric process always have reversed spectral profiles with respect to the center frequency of the pump.

12:30–13:30 Lunch Break *(on your own)*

Room A8

CLEO: QELS-Fundamental Science

QF2H • Periodic Materials Phenomena—Continued

QF2H.4 • 11:30
Integrated optical filters based on negative-index photonic crystals, Serdar Kocaman[1], Mehmet S. Aras[1], Nicolae Panoiu[2], Ming Lu[3], Chee Wei Wong[1]; *[1]Columbia University, USA; [2]University College London, United Kingdom; [3]Brookhaven National Laboratory, USA.* We demonstrate chip-scale flat-top filters at near-infrared wavelengths using negative index photonic crystal based Mach Zehnder interferometers. We further show that our approach can be used to design multi-level tunable filters.

QF2H.5 • 11:45
Bio-inspired tunable disorder in a 3D photonic crystal via highly controlled partial wetting and drying, Anna V. Shneidman[1], Ian B. Burgess[2,3], Mathias Kolle[2], Qimin Quan[2], Joanna Aizenberg[2,3], Marko Loncar[2]; *[1]Chemistry and Chemical Biology, Harvard University, USA; [2]School of Engineering and Applied Sciences, Harvard University, USA; [3]Wyss Institute for Biologically Inspired Engineering, Harvard University, USA.* We use highly controlled partial wetting in chemically encoded 3D photonic crystals to study tunable disorder in structurally colored systems. Our experimental and FDTD analyses also guide our design of a colorimetric indicator for organic liquids.

QF2H.6 • 12:00
Observation of dispersion-free edge states in honeycomb photonic lattices, Yonatan Plotnik[1], Mikael C. Rechtsman[1], Daohong Song[3], Matthias Heinrich[2], Alexander Szameit[2], Natalia Malkova[3], Zhigang Chen[3], Mordechai Segev[1]; *[1]Technion - Israel Institute of Technology, Israel; [2]physics, Institute of Applied Physics, Friedrich-Schiller-Universität, Germany; [3]San Francisco State University, USA.* We present the observation of dispersion-free edge states in a honeycomb lattice. We show the existence of surface states on both zigzag and bearded edges, and display their dispersion-free nature by tilting the input beam.

QF2H.7 • 12:15
Multimode PT-symmetric optical structures, Konstantinos Makris[1,2], Ramy El-Ganainy[3], Demetrios N. Christodoulides[4]; *[1]Materials Science and Technology Department, University of Crete, Greece; [2]Institute for Theoretical Physics, Vienna University of Technology, Austria; [3]Physics Department, University of Toronto, Canada; [4]College of Optics and Photonics, University of Central Florida, USA.* We examine the properties of multimoded PT-symmetric optical potentials. Multiple PT-thresholds, complex mode organization, vortices in the transverse power flow, and phase singularities, are few of the exotic characteristics of multimode PT-Optics.

Room B2 & B3

CLEO: Science & Innovations

CF2I • Optical Signal Processing—Continued

CF2I.5 • 11:30
A Linear Technique for Discrimination of Optically Coded Waveforms Using Optical Frequency Combs, Sharad P. Bhooplapur[1], Peter Delfyett[1]; *[1]College of Optics and Photonics, CREOL, University of Central Florida, USA.* We have demonstrated a coherent-detection architecture for an OCDMA system using only linear optical devices that successfully distinguishes between different users at record-low average power levels of ~30μW.

CF2I.6 • 11:45
Multi-output-port spectral pulse-shaping for simulating complex interferometric structures, Jochen Schroeder[1], Michaël A. Roelens[2], Liang B. Du[3], Arthur J. Lowery[3], Benjamin J. Eggleton[1]; *[1]Centre for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), Australia; [2]Finisar Australia, Australia; [3]Department of Electrical and Computer Systems Engineering, Monash University, Australia.* We demonstrate a novel spectral pulse shaper based reconfigurable interferometric filter with multiple output ports. Using this device we implement a DPSK and DQPSK demodulator and an all-optical discrete Fourier transform filter.

CF2I.7 • 12:00
A Method of Noise Suppression Using Feed Forward Loop for Injection Seeded WDM-PON with Low Injection Power, Sang-Rok Moon[1], Joon-Young Kim[1], Myeong gyun Kye[1], Chang-Hee Lee[1]; *[1]Electrical Engineering, Korea Advanced Institute of Science and Technology, Republic of Korea.* We propose a noise suppression method using a feed forward loop for injection seeded WDM-PON to enhance cost effectiveness.By using this method, the required injection power is decreased by 8 dB.

Room C1 & C2

CF2J • Next-Generation Photovoltaics I—Continued

CF2J.5 • 11:30
Polarization Enhanced Carrier Transport in a p-down n-GaN/i-InGaN/p-GaN Solar Cell Structure, Blair C. Connelly[1], Chad S. Gallinat[1], Nathaniel T. Woodward[1], Ryan W. Enck[1], Grace D. Metcalfe[1], Randy Tompkins[1], Shuai Zhou[1], Kenneth A. Jones[1], Hongen Shen[1], Michael Wraback[1]; *[1]U.S. Army Research Laboratory, USA.* Evidence of a strong electric field aiding carrier collection is observed in an n-GaN/i-InGaN/p-GaN inverted polarity solar cell structure, detected by pump-probe electroabsorption and THz spectroscopy.

CF2J.6 • 11:45
Large Area InGaN/GaN Nanowire Solar Cells on Silicon, Hieu P. Nguyen[1], Yukun Li[1], Zetian Mi[1]; *[1]Electrical and Computer Engineering Department, McGill University, Canada.* We have demonstrated, for the first time, large area InGaN/GaN nanowire solar cells on Si. An efficiency of ~0.19% is measured, which can be drastically improved by reducing the carrier localization and nonradiative surface recombination.

CF2J.7 • 12:00
Charge Transport of CdS/CdSe Co-sensitized Solar Cells, Kung-Hsuan Lin[1], Yu-Ming Chang[2], I-Ping Liu[3], Yuh-Lang Lee[3]; *[1]Institute of Physics, Academia Sinica, Taiwan; [2]Center for Condensed Matter Physics, National Taiwan University, Taiwan; [3]Chemical Engineering, National Cheng Kung University, Taiwan.* CdS, CdSe sensitized solar cells were investigated with excitation-wavelength-dependent, time-resolved photoluminescence technique and charge transport model. This approach is helpful to design semiconductor-sensitized and other types of solar cells.

CF2J.8 • 12:15
Thin-film Organic Photovoltaics With Double Plasmonic Nanostructures: the Metal Effect, Beibei Zeng[1], Qiaoqiang Gan[2], Zakya H. Kafafi[1,3], Filbert J. Bartoli[1]; *[1]Electrical and Computer Engineering Department, Lehigh University, USA; [2]Department of Electrical Engineering, The State University of New York at Buffalo, USA; [3]Department of Electrical and Systems Engineering, University of Pennsylvania, USA.* Broadband light absorption enhancement is numerically investigated for double plasmonic nanostructures in thin-film OPVs using Ag, Al, Au. A broadband, polarization-insensitive, and wide-angle absorption enhancement could be obtained.

Room C3 & C4

CF2K • Quantum Cascade Laser Design & Characterization—Continued

CF2K.5 • 11:30
Temperature Dependence of the Frequency Noise and Linewidth of a Mid-IR DFB Quantum Cascade Laser, Lionel Tombez[1], Stéphane Schilt[1], Joab Di Francesco[1], Pierre Thomann[1], Daniel Hofstetter[1]; *[1]Physics, Université de Neuchâtel, Switzerland.* We present the frequency noise and linewidth of a quantum cascade laser measured for the first time with the same device from cryogenic to room-temperature. A strong increase of the linewidth occurs at low temperature.

CF2K.6 • 11:45
Synchrotron Microspectroscopy of Quantum Cascade Laser Devices based on Quantum Wells and Quantum Dashes, Peter Friedli[1,2], Valeria Liverini[2], Andreas Hugi[2], Philippe Lerch[3], Jerome Faist[2], Hans Sigg[1]; *[1]Laboratory for Micro- and Nanotechnology, Paul Scherrer Institut, Switzerland; [2]Institute for Quantum Electronics, ETH Zurich, Switzerland; [3]Swiss Light Source, Paul Scherrer Institut, Switzerland.* We apply synchrotron-based Infrared broadband (0.08 - 1eV) transmission measurements of quantum cascade laser devices based on quantum wells and quantum dashes to determine qualitative and quantitative intersubband gain and waveguide losses.

CF2K.7 • 12:00
Direct Determination of Transparency Current in Mid-Infrared Quantum Cascade Laser, Dmitry Revin[1], Randa Hassan[1], Andrey Krysa[1], Kenneth Kennedy[1], Chris Atkins[1], John Cockburn[1], Yongrui Wang[2], Alexey Belyanin[2]; *[1]Department of Physics and Astronomy, The University of Sheffield, United Kingdom; [2]Department of Physics and Astronomy, Texas A&M University, USA.* Temperature dependent transparency current values have directly been extracted from the transmission spectra for the mid infrared quantum cascade laser. This current is found to contribute more than 65% to the threshold at room temperature.

CF2K.8 • 12:15
Direct link of a mid-infrared quantum cascade laser to a frequency comb by optical injection, Pablo Cancio[1]; Simone Borri[1]; *[1]CNR-INO, Italy.* A room-temperaturemid-infrared QCL is injection-locked by a narrow-linewidth comb-linked non-linear source. The QCL reproduces the injected radiation within [|#24#|]94%, with a frequency noise reduction of 3-4 orders of magnitude.

12:30–13:30 Lunch Break *(on your own)*

Marriott San Jose Salon I & II | Marriott San Jose Salon III | Marriott San Jose Salon IV

CLEO: Science & Innovations

CF2L • Ultrafast Devices—Continued

CF2L.5 • 11:30
Electrically-controlled Rapid Femtosecond Pulse Duration Switching in an Ultrafast Cr^{4+}:forsterite Laser, Christine E. Crombie[1], David A. Walsh[1], Weisheng Lu[2], Shiyong Zhang[3], Ziyang Zhang[3], Kenneth Kennedy[3], Stephane Calvez[2], Wilson Sibbett[1], Christian T. Brown[1]; [1]*SUPA School of Physics and Astronomy, University of St Andrews, United Kingdom;* [2]*Institute of Photonics, University of Strathclyde, United Kingdom;* [3]*EPSRC National Centre for III-V Technologies, University of Sheffield, United Kingdom.* We demonstrate fast switching between picosecond and femtosecond pulse durations from a Cr4+:forsterite laser, using an electrically-contacted GaInNAs SESAM whose absorption is controlled via the quantum confined Stark effect.

CF2L.6 • 11:45
Intrinsic Speed Limit of Graphene-based Photodetectors, Alexander Urich[1], Karl Unterrainer[1], Thomas Mueller[1]; [1]*Photonics Institute, Vienna University of Technology, Austria.* In this contribution, we present measurements of the intrinsic speed limit of graphene photodetectors using ultrashort laser pulses. We obtain a bandwidth of 262 GHz, showing the great potential of graphene for high-speed optoelectronics.

CF2M • Plasmonics and Light-Matter Interactions—Continued

CF2M.5 • 11:30
Transparent Conductive Oxides for Effective Low-Refractive-Index Ohmic Contact to Nanophotonic Devices demonstrated with Fabry-Perot Lasers, Fang Ou[1], Chunhan Hseih[1], Fei Yi[1], Yingyan Huang[2], Seng-Tiong Ho[1]; [1]*EECS, Northwestern University, USA;* [2]*OptoNet Inc, USA.* We show the possibility of using transparent conductive oxide for the current injection into nanophotonic devices. An InP based coplanar electrode Fabry-Perot micro-laser utilizing indium oxide as the N-type cladding electrode is demonstrated.

CF2M.6 • 11:45
Widely and continuously tuneable liquid crystal lasers, Philip J. Hands[1], Damian Gardiner[1], Stephen M. Morris[1], Qasim M. Malik[1], Timothy D. Wilkinson[1], Harry J. Coles[1]; [1]*Department of Engineering, University of Cambridge, United Kingdom.* Liquid crystal lasers offer continuously tuneable emissions across the visible and near-infrared in simple and compact architectures. Förster transfer techniques have extended the tuning range to 450-850nm, whilst utilizing a common pump source.

CF2M.7 • 12:00
Electrically-Controlled Thermal Infrared Metamaterial Devices, Young Chul Jun[1], Edward Gonzales[1], John Reno[1], Eric Shaner[1], Alon Gabbay[1], Igal Brener[1]; [1]*Sandia National Laboratories, USA.* We demonstrate electrically-controlled thermal mid-infrared metamaterials using depletion-type semiconductor devices. This electrical tuning can find novel applications in chip-scale active infrared devices.

CF2M.8 • 12:15
Transformation Optics with Planar Metamaterials: Diffraction Grating and Lens, Tapashree Roy[1], Andrey E. Nikolaenko[1], Edward T. Rogers[1], Nikolay I. Zheludev[1]; [1]*Optoelectronics Research Centre, University of Southampton, United Kingdom.* We use the resonance properties of elemental building blocks of metamaterial array with spatially variable parameter to control the phase and intensity of light beam. Dispersive and focusing devices are reported for the first time.

CF2N • High Power Fiber Lasers and Beam Combining—Continued

CF2N.5 • 11:30
Measurements of Phase Error Tolerance in Passive Coherent Beam Combining, James R. Leger[1], Chenhao Wan[1]; [1]*Electrical and Computer Engineering, Univ. of Minnesota, USA.* The effects of phase errors on lasers coherently coupled by a passive spatially filtered cavity are experimentally measured. We show that the phases must be kept within approximately ± 0.1 radians to maintain coherence.

CF2N.6 • 11:45
Conceptual study on planar-core optical fiber for high power fiber lasers, Yasushi Fujimoto[1], Motoichiro Murakami[1], Takanori Matsumura[1,2], Hitoshi Nakano[2], Tatsuhiro Sato[3]; [1]*Institute of Laser Engineering, Osaka Univeristy, Japan;* [2]*Faculty of science and Engineering, Kinki University, Japan;* [3]*Research and Application Laboratory, Shin-Etsu Quartz Products Co., Ltd., Japan.* We present a new concept of planar-core optical fiber and show a fabricated planar-core fiber and a laser oscillation demonstration. The planar-core fiber will work as a medium of high power fiber lasers.

CF2N.7 • 12:00
Dynamics and Origin of Mode Instabilities in High Power Fiber Laser Amplifiers, Hans-Jürgen Otto[1], Cesar Jauregui[1], Tino Eidam[1], Fabian Stutzki[1], Florian Jansen[1], Jens Limpert[1,2], Andreas Tünnermann[1,3]; [1]*Fiber- and Waveguide Lasers, Institute of Applied Physics, Germany;* [2]*Helmholtz-Institute Jena, Germany;* [3]*Fraunhofer Institute for Applied Optics and Precision Engineering, Germany.* The temporal behavior of mode instabilities is investigated. These results support the thermal origin of this effect, and, in particular, the creation of a thermally-induced long period grating by the beating of two transversal modes.

CF2N.8 • 12:15
Efficient Coherent Beam Combining of Fiber Lasers Using Multiplexed Volume Bragg Gratings, Apurva Jain[1], Christine Spiegelberg[2], Vadim Smirnov[2], Leonid Glebov[1], Erik Bochove[3]; [1]*CREOL, The College of Optics and Photonics, University of Central Florida, USA;* [2]*OptiGrate Corp., USA;* [3]*Air Force Research Laboratory, USA.* Highly efficient, stable, and scalable passive coherent beam combining of fiber lasers using multiplexed volume Bragg gratings is presented. We report combining efficiency of >90% for two channels and demonstrate channel scalability to four channels.

12:30–13:30 Lunch Break *(on your own)*

Room A1 | Room A2 | Room A3 | Room A4

CLEO: Science & Innovations

CLEO: QELS-Fundamental Science

13:30–15:30
CF3A • Nonlinear Materials and Devices
Sunao Kurimura, National Institute for Material Science, Japan, *Presider*

CF3A.1 • 13:30
Novel 1,2,3-triazole based compounds as quadratic nonlinear optical crystals, Daniel Lumpi[1], Florian Glöcklhofer[1], Berthold Stöger[2], Georg A. Reider[3], Christian Hametner[1], Ernst Horkel[1], Johannes Fröhlich[1]; *[1]Institute of Applied Synthetic Chemistry, Vienna University of Technology, Austria; [2]Institute of Chemical Technologies and Analytics, Vienna University of Technology, Austria; [3]Photonics Institute, Vienna University of Technology, Austria.* Systematic investigations towards a novel class of quadratic NLO materials, based on the application of 1,2,3-triazole moieties, are outlined to afford organic crystals displaying SHG nonlinearities of more than 9 times the value of KDP.

CF3A.2 • 13:45
Nd3+-doped Bi2O3-B2O3-TeO2 glass for solar pumped lasers, Yuya Shimada[1], Seiki Ohara[1]; *[1]Reseach center, Asahi Glass Co., Ltd., Japan.* We have studied Nd3+-doped Bi2O3-B2O3-TeO2 glasses for solar pumped lasers, and compared with silicate glasses and YAG ceramics. Bi2O3-B2O3-TeO2 glasses show broad band and large absorption compared to YAG ceramics, and longer fluorescence lifetime.

CF3A.3 • 14:00
Energy-transfer processes in Al2O3:Er3+ waveguide amplifiers, Laura Agazzi[1], Kerstin Wörhoff[1], Markus Pollnau[1]; *[1]IOMS group, University of Twente, Netherlands.* The influence of migration-accelerated energy-transfer upconversion and fast luminescence quenching on Al2O3:Er3+ waveguide amplifiers is investigated. Results indicate that the latter has the stronger impact on the amplifier small-signal gain.

CF3A.4 • 14:15
189-nm Wavelength Generation with Borate Crystals, Chen Qu[1,2], Masashi Yoshimura[1,2], Jun Tsunoda[1,2], Yushi Kaneda[1,3], Mamoru Imade[1], Takatomo Sasaki[1,2], Yusuke Mori[1,2]; *[1]Div of EEIE, Grad School of Eng, Osaka Univ, Japan; [2]CREST, JST, Japan; [3]College of Optical Sciences, The University of Arizona, USA.* The phase-matching properties of borate crystals were investigated for vacuum ultraviolet light generation. A 189-nm output of 8.2 mW was observed with CLBO while new phase-matching property of CBO was found.

13:30–15:30
CF3B • Mid-infrared Parametric Sources
Peter Schunemann, BAE Systems Inc., *Presider*

CF3B.1 • 13:30 Invited
Mid-IR Frequency Combs Based on Subharmonic GaAs OPO, Konstantin Vodopyanov[1]; *[1]Stanford University, USA.* We produce broadband frequency combs using degenerate sync-pumped OPO based on orientation-patterned GaAs pumped by an ultrafast laser. With a 2050-nm Tm-fiber femtosecond laser pump, the OPO instantaneous spectral span approaches 3-6 µm.

CF3B.2 • 14:00
Tunable Mid-Infrared Source Based on Difference Frequency Generation of a Femtosecond Tm-fiber System in Orientation Patterned GaAs, Christopher R. Phillips[1], Carsten Langrock[1], Martin M. Fejer[1], Jie Jiang[2], Ingmar Hartl[2], Martin E. Fermann[2], Angie Lin[3], James Harris[3], Michael Snure[4], David Bliss[4], Miao Zhu[5]; *[1]Ginzton Laboratory, Stanford University, USA; [2]IMRA America, Inc., USA; [3]Solid State Photonics Laboratory, Stanford University, USA; [4]Air Force Research Laboratory, Wright-Patterson Air Force Base, USA; [5]Agilent Laboratories, Agilent Technologies, USA.* We demonstrate a mid-infrared source tunable from 6.7-12.7 µm via difference frequency generation in orientation-patterned GaAs, with 1.3 mW average output power. The input pulses are generated from a femtosecond Tm-doped-fiber laser system.

CF3B.3 • 14:15
Nearly 3-6µm Spectral Comb Derived from Tm Mode-locked Laser using GaAs-based Degenerate OPO, Nick Leindecker[1], Alireza Marandi[1], Robert L. Byer[1], Konstantin L. Vodopyanov[1], Jie Jiang[2], Ingmar Hartl[2], Martin E. Fermann[2], Peter G. Schunemann[3]; *[1]E.L. Ginzton Laboratory, Stanford, USA; [2]IMRA America, Inc., USA; [3]BAE Systems, USA.* We use a degenerate OPO pumped by an ultrafast 2050-nm Tm-fiber laser to generate a broadband mid-infrared comb. A GaAs gain element and dispersion management access an ~octave-wide output spectrum extending from 3.1 to 5.9µm.

13:30–15:30
CF3C • Precision Imaging and Sensing
Brian Washburn, Kansas State University, USA, *Presider*

CF3C.1 • 13:30
Terahertz Chirp Generation Using Frequency Stitched VCSELs for Increased LIDAR Resolution, Arseny Vasilyev[1], Naresh Satyan[1], George Rakuljic[2], Amnon Yariv[1]; *[1]Applied Physics, California Institute of Technology, USA; [2]Telaris Inc., USA.* We stitch the frequency chirps of two vertical-cavity surface-emitting lasers in a frequency-modulated imaging experiment at 1550nm. The effective frequency excursion is 1 THz, corresponding to a free-space axial resolution of 150 micrometers.

CF3C.2 • 13:45
High-resolution Ranging of a Diffuse Target at Sub-Millisecond Intervals with a Calibrated FMCW Lidar, Fabrizio R. Giorgetta[1], Esther Baumann[1], Kevin Knabe[1], Ian Coddington[1], Nathan R. Newbury[1]; *[1]NIST, USA.* We demonstrate a FMCW Lidar with a frequency-calibrated laser modulated over 1 THz at ~1 kHz modulation frequency. Range to a diffuse target is measured at 0.5 ms intervals with 150 um resolution and ~1 um precision.

CF3C.3 • 14:00
A MEMS Controlled Cavity Optomechanical Sensing System, Houxun Miao[1,2], Kartik Srinivasan[1], Vladimir Aksyuk[1]; *[1]NIST, USA; [2]University of Maryland, USA.* We report an integrated MEMS sensing platform enabled by cavity optomechanics. We demonstrate 4.6 fm/Hz1/2 displacement sensitivity for sub-µW input power, tunable readout gain, and feedback damping of mechanical response by a factor of >1000.

CF3C.4 • 14:15
Demonstration of OAM Mode Distortions Monitoring using Interference-Based Phase Reconstruction, Hao Huang[1], Yongxiong Ren[1], Nisar Ahmed[1], Yan Yan[1], Yang Yue[1], Amanda Bozovich[1], Jeng-Yuan Yang[1], Alan Willner[1], Kevin Birnbaum[2], Baris Erkmen[2], John Choi[2], Sam Dolinar[2]; *[1]University of Southern California, USA; [2]Jet Propulsion Lab, USA.* We present OAM distortion monitoring by using an interferometer with 90-degree phase-shift for phase reconstruction without spatial scanning. Monitoring of distortion caused by misalignment and atmospheric turbulence are successfully demonstrated.

13:30–15:30
QF3D • Nano- and Near-Field Spectroscopy
Mario Hentschel, University of Stuttgart, Germany, *Presider*

QF3D.1 • 13:30 Invited
Infrared Nanophotonics, Rainer Hillenbrand[1]; *[1]CIC nanoGUNE, Spain.* We show that mid-infrared light can be focused to nanoscale spots ("hot spots") by employing plasmonic antenna structures and tapered transmission lines. Applications such as nanoscale-resolved infrared spectroscopic imaging will be demonstrated.

QF3D.2 • 14:00
Thermal Near-field Optical Spectroscopy, Andrew C. Jones[2,1], Markus B. Raschke[1,2]; *[1]Physics, University of Colorado, USA; [2]Department of Physics, University of Washington, USA.* Scattering near-field microscopy with heated tips is used to characterize the spatially and spectrally distinct IR thermal near-field demonstrating for the first time the resonant enhancement of the underlying electromagnetic local density of states.

QF3D.3 • 14:15
Surface Plasmon Polariton Raman Microscopy, Chris A. Michaels[1], Hae-Wook Yoo[2], Hee-Tae Jung[2], Lee Richter[1]; *[1]Material Measurement Laboratory, NIST, USA; [2]Chemical and Biomolecular Engineering, KAIST, Republic of Korea.* We report surface plasmon polariton (SPP) mediated Raman microscopy on dielectric films in contact with a Ag layer at 785 nm with spatial resolution approaching the optical diffraction limit and reasonable spectral acquisition times.

Room A5 | Room A6 | Room A7

CLEO: QELS-Fundamental Science

13:30–15:00
QF3E • Quantum Optics of Atoms and Solids
Sergey Polyakov, NIST, USA, *Presider*

QF3E.1 • 13:30
Logarithmically Diverging Two-photon Spectrum: Anomalous Scale Symmetry Breaking in Two Dimensions, Nir Davidson[1], Rami Pugatch[1], Dipankar Bhattacharyya[1], Yoav Sagi[1], Ariel Amir[1]; [1]*Weizmann Institute of Science, Israel.* For small area beams, the two-photon spectra of atoms diffusing in hot buffer gas approaches a universal, logarithmically-diverging shape, connected to anomalous scale symmetry breaking of with a delta-function potential.

QF3E.2 • 13:45
Interplay of χ(3) and χ(3) processes in a double-ladder system, Paul S. Hsu[1,2], George R. Welch[2], James R. Gord[3], Anil K. Patnaik[3,4]; [1]*Spectral Energies, LLC, USA;* [2]*Physics, Texas A&M University, USA;* [3]*Air Force Research Laboratory, USA;* [4]*Physics, Wright State University, USA.* The interplay of χ(1) and χ(3) processes in a double-ladder system is investigated to demonstrate controllability of cross-talk between two probes propagating through the medium.

QF3E.3 • 14:00
Generation of a macroscopic singlet state in an atomic ensemble, Naeimeh Behbood[1], Mario Napolitano[1], Giorgio Colangelo[1], Brice Dobust[1,2], Silvana Palacios Á lvarez[1], Robert Sewell[1], Geza Tóth[3], Morgan W. Mitchell[1]; [1]*ICFO-The Institute of Photonic Sciences, Spain;* [2]*Univ Paris Diderot, Sorbonne Paris Cite, Laboratoire Materiaux et Phenomenes Quantiques, France;* [3]*Theoretical Physics and History of Science, The University of the Basque Country, Spain.* We report on an experiment for generating singlet states in a cold atomic ensemble. We use quantum non-demolition measurement and feedback control to produce a macroscopic spin state with total spin zero and reduced spin fluctuations.

QF3E.4 • 14:15
Enhancement of electromagnetically-induced transparency in a multilevel broadened medium, Michael Scherman[1], Oxana S. Mishina[1], Pietro Lombardi[1], Elisabeth Giacobino[1], Julien Laurat[1]; [1]*Laboratoire Kastler Brossel, France.* We experimentally demonstrate that electromagnetically-induced transparency in a vapor of alkali-metal atoms can be strongly enhanced via a specific shaping of the atomic velocity distribution.

13:30–15:30
QF3F • Entanglement
Nobuyuki Matsuda, NTT Basic Research Laboratories, Japan, *Presider*

QF3F.1 • 13:30
Four-Photon Polarization-Entangled States with Minimal Spectral and Spatial Entanglement, Warren Grice[1,3], Jason Schaake[3], Travis Humble[2]; [1]*Computational Sciences and Engineering, Oak Ridge National Lab, USA;* [2]*Computer Science and Mathematics, Oak Ridge National Lab, USA;* [3]*Physics and Astronomy, University of Tennessee, USA.* We present two schemes for generating four-photon states: one for direct GHZ state generation and another yielding an entire class of polarization-entangled states. Both begin with photon pairs having minimal spectral and spatial entanglement.

QF3F.2 • 13:45
Quantum state tomography using photon number counting to evaluate entanglement generated by spontaneous parametric downconversion, Akio Yoshizawa[1], Daiji Fukuda[1], Hidemi Tsuchida[1]; [1]*National Institute of Advanced Industrial Science and Technology (AIST), Japan.* We analyze polarization-entangled photon pairs using detectors that can or cannot count photons to discuss accuracy of the fidelity estimated by quantum state tomography. The use of four photon-number-resolving detectors presents best accuracy.

QF3F.3 • 14:00
Polarization/Time-bin basis conversion of entangled photons, Jonathan Hodges[1], Stephen Pappas[1], Yaakov Weinstein[1], Gerry Gilbert[1]; [1]*MITRE Corp, USA.* We describe a scheme for interconverting photonic entanglement between time-bin and polarization bases. This scheme makes entangled pairs insensitive to birefringement effects and thus has application in fiber-based quantum memories.

QF3F.4 • 14:15
Direct measurements of the non-classicality degree in photon-number correlations, Liat Dovrat[1], Michael Bakstein[1], Daniel Istrati[1], Eli Megidish[1], Assaf Halevy[1], Lior Cohen[1], Hagai S. Eisenberg[1]; [1]*Racah Institute of Physics, The Hebrew University of Jerusalem, Israel.* Using photon-number resolving detectors, we directly measure the two-mode photon-number distribution of parametric down-conversion for different degrees of correlation. We present two quantitative measures for the degree of non-classicality.

13:30–15:30
QF3G • Nonlinear Frequency Mixing Phenomena
Yujie Ding, Lehigh University, USA, *Presider*

QF3G.1 • 13:30 Invited
Photon Extrabunching in Twin Beams Beams in the Femtosecond Range Measured by Two-Photon Counting in a Semiconductor, Fabien Boitier[1], Antoine Godard[1], Nicolas Dubreuil[2], Philippe Delaye[2], Claude Fabre[3], Emmanuel Rosencher[1,4]; [1]*ONERA - the French Aerospace Lab, France;* [2]*Laboratoire Charles Fabry (Institut d'Optique, CNRS, Univ Paris-Sud, France;* [3]*Laboratoire Kastler Brossel, Ecole Normale Supérieure and University Pierre et Marie Curie, France;* [4]*Physics Department, Ecole Polytechnique, France.* Correlations of twin beams generated by parametric down-conversion are quantitatively determined by two-photon counting interferometery. Compared with incoherent light, photon extrabunching at the fs scale is unambiguously and precisely measured.

QF3G.2 • 14:00
Generation of Terahertz Pulses by Mixing Dual-Frequency Pulses from Yb:YAG Laser, Pu Zhao[1], Srinivasa Ragam[1], Yujie J. Ding[1], Ioulia B. Zotova[2]; [1]*Electrical & Computer Engineering, Lehigh University, USA;* [2]*ArkLight, USA.* We have demonstrated that terahertz pulses at 1.65 THz can be generated by mixing dual-frequency pulses emitted from a compact broadband Q-switched Yb:YAG laser.

QF3G.3 • 14:15
Triple resonant four-wave mixing: A microwatt continuous-wave laser source in the vacuum ultraviolet region at 120 nm, Daniel Kolbe[1,2], Thomas Diehl[1,2], Andreas Koglbauer[1,2], Matthias Sattler[1,2], Matthias Stappel[1,2], Ruth Steinborn[1,2], Jochen Walz[1,2]; [1]*Institut für Physik, Johannes Gutenberg-Universität, Germany;* [2]*Helmholtz Institut, Johannes Gutenberg-Universität, Germany.* We present a vacuum ultraviolet laser source by four-wave mixing in mercury vapour based on solid-state laser systems. Maximum powers of 6 μW were achieved with an increase of four orders of magnitude in efficiency.

Room A8

CLEO: QELS-Fundamental Science

13:30–15:30
QF3H • Photonic Crystals II
Hui Cao, Yale University, USA, *Presider*

QF3H.1 • 13:30
Specular amorphous photonic bandgap lattices, Peng Zhang[1], Peigen Ni[1], Xinyuan Qi[1,2], Weining Man[1], Zhigang Chen[1,3], Jianke Yang[4], Mikael Rechtsman[5], Mordechai Segev[5]; *[1]1Department of Physics and Astronomy, San Francisco State Univ, USA; [2]Department of Physics and Astronomy, Northwest University, China; [3]3TEDA Applied Physics School, Nankai Univ, China; [4]Department of Mathematics and Statistics, University of Vermont, USA; [5]Physics Department and Solid State Institute, Israel.* We show theoretically and experimentally that photonic lattices constructed from random components residing on a ring in momentum space are amorphous, yet they exhibit a bandgap, and support linear and nonlinear defect-state guidance.

QF3H.2 • 13:45
Experimental demonstration of guiding, bending, and filtering of electromagnetic wave in disordered photonic band gap materials, Weining Man[1], Marian Florescu[2], Seyed Hashemizad[1], Yingquan He[1], Brian Leung[1], Eric Williamson[1], Paul Chaikin[3]; *[1]Physics and Astronomy, San Francisco State University, USA; [2]Advanced Technology Institute and Department of Physics,, University of Surrey,, United Kingdom; [3]Department of Physics, New York University, USA.* We report the first experimental demonstration of guiding, bending, filtering, and splitting of EM wave in 2D disordered PBG materials, along arbitrarily curved paths, around sharp bends of arbitrary angles, and through Y shape junctions.

QF3H.3 • 14:00
Exploiting the Time-Reversal Operator for Adaptive Optics, Selective Focusing and Scattering Pattern Analysis, Sebastien M. Popoff[1], Alexandre Aubry[1], Geoffroy Lerosey[1], Mathias Fink[1], A. Claude Boccara[1], Sylvain Gigan[1]; *[1]Institut Langevin - ESPCI ParisTech, France.* We report on the optical measurement of the backscattering matrix in a weakly scattering medium. A decomposition of the time reversal operator allows selective and efficient focusing on individual scatterers, even through an aberrating layer.

QF3H.4 • 14:15
Cavities without confinement barrier in incommensurate photonic crystal superlattices, Zhiyuan Li[1], Chen Wang[1]; *[1]Laboratory of Optical Physics, Institute of Physics, Chinese Academy of Sciences, China.* We fabricate cavities without confinement by combining two incommensurate photonic crystal superlattice waveguides. The experiment confirms a resonant mode showing up in the pass band of waveguide and the Anderson localization within photonic bands.

Room B2 & B3

CLEO: Science & Innovations

13:30–15:15
CF3I • Space Division Multiplexing (SDM)
E. Bert Basch, Verizon Communications Inc., USA, *Presider*

CF3I.1 • 13:30 Invited
Design and Modeling of Novel Fibers for Space Division Multiplexing, John M. Fini[1]; *[1]OFS Labs, USA.* New fibers carrying spatially multiplexed signals will drastically increase capacity per fiber in long-haul communications. Fiber irregularity and length variation will ultimately determine the performance limits of SDM fibers.

CF3I.2 • 14:00
Dynamic Detector Selection for Multiple-Input Multiple-Output (MIMO) Multimode Fiber Links, Kumar Appaiah[1], Sagi Zisman[1], Sriram Vishwanath[1], Seth Bank[1]; *[1]The University of Texas at Austin, USA.* We propose a dynamic greedy selection algorithm to reduce computational requirements in multimode MIMO fiber links employing a photodetector array. Simulations reveal that ~90% of capacity is achievable from only a small subset of photodetectors.

CF3I.3 • 14:15
LDPC-Coded Mode-Multiplexed CO-OFDM over 1000 km of Few-Mode Fiber, Ding Zou[1], Changyu Lin[1], Ivan B. Djordjevic[1]; *[1]Electrical and computer engneering, University of Arizona, USA.* We demonstrate by simulations that four independent LDPC-coded 80Gb/s QPSK OFDM signals can be transmitted by mode-multiplexing over 1000km of few-mode fiber using coherent detection with a powerful channel estimation technique.

Room C1 & C2

13:30–15:30
CF3J • Novel Materials and Approaches for "Green" Photonics
Leo Schowalter, Crystal IS Inc., USA, *Presider*

CF3J.1 • 13:30 Invited
Graphene Photonics and Optoelectroncs, Andrea C. Ferrari[1]; *[1]Engineering Department, University of Cambridge, United Kingdom.* Graphene has great potential in photonics and optoelectronics. I will review the state of the art in this emerging field of research, focussing on flexible and transparent conductors, photoluminescence, photodetectors, non-linear optics, and ultrafast lasers.

CF3J.2 • 14:00
Application of Printable ITO/PEDOT Nanocomposites as Transparent Electrodes in Optoelectronic Devices, Ilja Maksimenko[1], Peter Wellmann[1], Wolfgang Peukert[2], Daniel Kilian[2], Christian Mehringer[2], Michael Voigt[2]; *[1]Materials Science and Engineering 6, University of Erlangen-Nuremberg, Germany; [2]Institute of Particle Technology, University of Erlangen-Nuremberg, Germany.* Printable transparent hybrid composites consisting of ITO nanoparticles and conducting polymer PEDOT as matrix material were developed and used as transparent electrodes in all-printed flexible electroluminescent lamps and electrochromic displays.

CF3J.3 • 14:15
Design and Fabrication of Polymer-Fiber-based Luminescent Solar Concentrator Fabrics, Esmaeil-Hooman Banaei[1], Ayman F. Abouraddy[1]; *[1]CREOL, The College of Optics & Photonics, University of Central Florida, CREOL, USA.* We present the design and fabrication of all-polymer optical fiber luminescent solar concentrators. Large-area, lightweight, and flexible fabrics constructed of such fibers are a low-cost solar-energy alternative useful for mobile applications.

Room C3 & C4

13:30–15:30
CF3K • ICLs and QCL Waveguide Design
Dan Wasserman, University of Illinois, USA, *Presider*

CF3K.1 • 13:30
Room-Temperature InAs-based Interband Cascade Lasers, Yuchao Jiang[1], Lu Li[1], Zhaobing Tian[1], Robert T. Hinkey[1,2], Rui Q. Yang[1], Tetsuya D. Mishima[2], Michael B. Santos[2], Matthew B. Johnson[2], Kamjou Mansour[3]; *[1]School of Electrical and Computer Engineering, University of Oklahoma, USA; [2]Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, USA; [3]Jet Propulsion Laboratory, California Institute of Technology, USA.* We report the demonstration of InAs-based interband cascade lasers at temperatures up to 315 K and 253 K operating in pulsed and continuous wave modes, respectively, near 5.3 microns.

CF3K.2 • 13:45
Interband Cascade Lasers at Long Wavelengths, Lu Li[1], Zhaobing Tian[1], Yuchao Jiang[1], Hao Ye[1], Rui Q. Yang[1], Tetsuya D. Mishima[1], Michael B. Santos[2], Matthew B. Johnson[2]; *[1]School of Electrical and Computer Engineering, University of Oklahoma, USA; [2]Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, USA.* We report the demonstration of InAs-based interband cascade lasers in a temperature range from 80 to 260 K operating in pulsed and continuous wave modes at wavelengths near 6.0, 7.4, and 10.3 microns.

CF3K.3 • 14:00
Wavelength Tuning of Sampled-Grating DBR Quantum Cascade Lasers, Abdou S. Diba[1,2], Feng Xie[1], Catherine Caneau[1], Herve LeBlanc[1], Sean Coleman[1], Chung-en Zah[1]; *[1]Science and Technology, Corning Inc., USA; [2]Electrical Engineering, The City College of New York, USA.* We characterized the performance of sampled-grating distributed Bragg reflectors (SG DBR) quantum cascade lasers (QCLs) and demonstrated a wide wavelength tuning from 4.48 to 4.69 μm (100cm-1) by injecting current into the SGDBR sections.

CF3K.4 • 14:15
Post-fabrication wavelength selection and spectral narrowing of Quantum Cascade lasers via application of a shallow distributed Bragg reflector, Arash Sadeghi[1], Peter Q. Liu[1], Claire Gmachl[1]; *[1]Electrical Engineering, Princeton University, USA.* Application of a shallow distributed Bragg reflector ion-milled on a tenth of the laser ridge leads to spectral narrowing, a 10-fold reduction in full-width-half-maximum and ~12dB side mode suppression, of Fabry-Perot type QC lasers.

Marriott San Jose Salon I & II | **Marriott San Jose Salon III** | **Marriott San Jose Salon IV**

CLEO: Science & Innovations

13:30–15:30
CF3L • Ultrafast Mode-locking Dynamics
Gunter Steinmeyer, Max Born Institute, Germany, *Presider*

CF3L.1 • 13:30
Characteristics and instabilities of mode-locked quantum-dot diode lasers, Daniel J. Kane[1]; [1]*Mesa Photonics, USA.* Passively mode-locked quantum-dot diode lasers are very difficult to characterize because they are typically unstable, have low peak powers, and high bandwidth. Measure data indicates these lasers are not typically mode-locked.

CF3L.2 • 13:45
Kerr-lens mode-locked Yb:KYW laser at 3.3-GHz repetition rate, Mamoru Endo[1], Akira Ozawa[1], Yohei Kobayashi[1]; [1]*The Institute for Solid State Physics, University of Tokyo, Japan.* We developed a laser-diode pumped, 3.32-GHz repetition-rate, Yb:KYW Kerr-lens mode-locked laser with a bowtie cavity. The spectrum width is 10 nm around 1050 nm with the output power of 13.5 mW.

CF3L.3 • 14:00
Nonlinear-polarization-evolution mode-locking in a hybrid cavity: a route toward low repetition-rate fiber lasers, Yue Zhou[1,2], Guoqing Chang[1], Hung-Wen Chen[1], Po Ching Chui[2], Kenneth K. Y. Wong[2], Franz X. Kaertner[1,3]; [1]*Massachusetts Institute of Technology, USA;* [2]*The University of Hong Kong, Hong Kong;* [3]*Center for Free-Electron Laser Science, DESY and University of Hamburg, Germany.* We demonstrate an Yb-fiber oscillator consisting of both polarization-maintaining (PM) and non-PM fibers. A femtosecond Yb-fiber oscillator at 12-MHz repetition-rate with 10-nJ pulse energy is implemented employing this hybrid cavity.

CF3L.4 • 14:15
Large Area SBRs for Ultra-short Pulse Generation, Sheila Nabanja[1]; [1]*EECS, Massachusetts Institute of Technology, USA.* Fabrication and characterization of ultra-broadband III-V/AlxOy Saturable Bragg Reflectors as mesas as well as inverted mesa structures for ultra-short pulse generation is presented along with a physical model of the oxidation process.

13:30–15:30
CF3M • Nonlinear Optics in Nanophotonic Structures III
Shayan Mookherjea, University of California San Diego, USA, *Presider*

CF3M.1 • 13:30 Invited
Microresonator-based Optical Frequency Combs, Tobias Kippenberg[1]; [1]*Ecole Polytechnique Federale de Lausanne (EPFL) and Max Planck Inst. of Quantum Optics (MPQ), Switzerland.* Mid and near-IR optical frequency combs generation in ultra high Q crystalline and integrated SiN microcavities is presented. Moreover, universal dynamics that influences phase noise is described.

CF3M.2 • 14:00
Photonic chip based tunable slow and fast light via stimulated Brillouin scattering, Ravi Pant[1], Adam Byrnes[1], Christopher G. Poulton[2], Enbang Li[1], Duk-Yong Choi[3], Steve J. Madden[3], Barry Luther-Davies[3], Benjamin J. Eggleton[1]; [1]*School of Physics, University of SYdney, Australia;* [2]*School of Mathematical Sciences, University of Technology Sydney, Australia;* [3]*Laser Physics Centre, Australian National University, Australia.* We report the first demonstration of on-chip tunable slow- and fast-light via stimulated Brillouin scattering. We observe group-index ranging from ~-44 to +130 in a 7cm long chalcogenide waveguide at a low gain of ~23dB.

CF3M.3 • 14:15
Broadband Polarization-Insensitive Wavelength Conversion Based on Non-Degenerate Four-Wave Mixing in a Silicon Nanowire, Minhao Pu[1], Hao Hu[1], Hua Ji[1], Michael Galili[1], Leif K. Oxenløwe[1], Palle Jeppesen[1], Jørn M. Hvam[1], Kresten Yvind[1]; [1]*DTU Fotonik, Photonics Engineering, Technical Univ. of Denmark, Denmark.* We experimentally demonstrate broadband polarization-insensitive one-to-two wavelength conversion of a 10-Gb/s DPSK data signal based on non-degenerate four-wave mixing in a silicon nanowire with bit-error rate measurements.

13:30–15:30
CF3N • Fiber DFB's and Nonlinear Effects
Robert Jopson, Bell Labs, Alcatel-Lucent, USA, *Presider*

CF3N.1 • 13:30 Invited
Stimulated Brillouin Scattering in Specialty Optical Fibers: Importance of Material, Structure and Manufacturing Parameters, Yves Jaouën[1], Guillaume Canat[2], Yolande Sikali Mamdem[3], Renaud Gabet[1], Laurent Lombard[2], Ekaterina Burov[4]; [1]*Telecom ParisTech, France;* [2]*ONERA, France;* [3]*EDF R&D, France;* [4]*DRAKA Communications, France.* The influence of material doping profile and geometrical structure on Brillouin gain characteristics has been investigated. Based on a FEM modeling, importance of internal residual stress induced by fiber drawing conditions is also pointed out.

CF3N.2 • 14:00
Strong Brillouin suppression in a fiber ring cavity, Jae K. Jang[1], Stuart G. Murdoch[1]; [1]*Physics, University of Auckland, New Zealand.* We demonstrate an over sixty-times increase in the Brillouin threshold of a short length fiber ring cavity through careful selection of the fiber length.

CF3N.3 • 14:15
Distributed Birefringence Measurement of a 500-m Polarization-Maintaining Fiber with a 20-cm Resolution Based on Brillouin Dynamic Grating, Yongkang Dong[1,3], Hongying Zhang[2,3], Zhiwei Lu[1], Liang Chen[3], Xiaoyi Bao[3]; [1]*Institute of Opto-Electronics, Harbin Institute of Technology, China;* [2]*Department of optics information science and technology, Harbin University of Science and Technology, China;* [3]*Department of Physics, University of Ottawa, Canada.* We propose a novel scheme to realize distributed birefringence measurement over a 500-m polarization-maintaining fiber with a 20-cm resolution based on Brillouin dynamic grating, observing three characteristic periods of the birefringence variation.

Room A1 | Room A2 | Room A3 | Room A4

CLEO: Science & Innovations

CLEO: QELS-Fundamental Science

CF3A • Nonlinear Materials and Devices—Continued

CF3A.5 • 14:30
PMMA copolymerized with polyacrylonitrile as novel host material for host-guest type second-order NLO polymers, Atsushi Sugita[1], Yasuaki Tamaki[1], Nobuyuki Mase[1], Wataru Inami[1], Yoshimasa Kawata[1], Shigeru Tasaka[1]; *[1]Shizuoka University, Japan.* We will present second-order NLO susceptibility of non-electrically poled NLO chromophore-doped PMMA copolymerized with polyacrylonitrile. The second-order nonlinear coefficient of 2 pm/V was obtained without conventional poling procedure.

CF3A.6 • 14:45
CW-pumped +11.6 dB gain in DFG using an efficient QPM adhered-ridge waveguide, Yusuke Muranaka[1,2], Kaori Sugiura[1,2], Sunao Kurimura[1,2], Rai Kou[1,2], Kiyofumi Kikuchi[1,2], Hirochika Nakajima[2], Junichiro Ichikawa[3]; *[1]National Institute for Materials Science, Japan; [2]Waseda University, Japan; [3]Sumitomo Osaka Cement Co., LTD., Japan.* We recorded the maximum channel conversion efficiency of +11.6 dB in DFG with 330 mW CW pump using Mg:LiNbO3-based QPM adhered-ridge-waveguide wavelength converter and discussed theoretical conversion efficiency for nonlinear optical effects.

CF3A.7 • 15:00
Achromatically Coupled Wavelength Conversion Module with SILICAGRIN® Lens, Kaori Sugiura[1,2], Sunao Kurimura[1,2], Yusuke Muranaka[1,2], Kiyofumi Kikuchi[1,2], Taro Suzuki[3], Hirochika Nakajima[2], Junichiro Ichikawa[4]; *[1]National Institute for Materials Science, Japan; [2]Waseda University, Japan; [3]TOYO GLASS Co., Ltd., Japan; [4]Sumitomo Osaka Cement Co., Ltd., Japan.* We develop a parametric wavelength conversion module with low chromatic dispersion using SILICAGRIN® optical fiber condenser. Less than 1 dB of the insertion loss difference between wavelength 780 nm and 1550 nm is achieved.

CF3A.8 • 15:15
Development of efficient broadband green light source by tandem quasi-phase-matched structure, Nan Ei Yu[1], Ju Won Choi[1], Heejong Kang[1], Do-Kyeong Ko[1], C.-m. Ho[2], S.-h. Fu[2], C.-w. Hsu[2], C.-y. Chu[2], C.-l. Chen[2], W.-s. Wang[2], L.-h. Peng[2], Andy Kung[3], Hee Joo Choi[4], Byoung Joo Kim[4], Myoungsik Cha[4]; *[1]Gwangju Institute of Science and Technology, Republic of Korea; [2]National Taiwan University, Taiwan; [3]National Tsing-Hua University, Taiwan; [4]Pusan National University, Republic of Korea.* Broadband green light source using a 5.5-mm-long tandem PPLN was demonstrated. The measured wavelength and temperature bandwidth were 13nm and 100°C, respectively, which had 34.2 times broader spectral bandwidth than periodic one.

CF3B • Mid-infrared Parametric Sources—Continued

CF3B.4 • 14:30
Mid-infrared cascaded parametric source in 6 µm region for medical applications, Georg Stoeppler[1], Nicky Thilmann[2], Marc Eichhorn[1], Valdas Pasiskevicius[2], Andrius Zukauskas[2], Carlota Canalias[2]; *[1]French-German Research Institute of Saint Louis, ISL, France; [2]Royal Institute of Technology, KTH, Sweden.* All-diode-pumped parametric source generating 5ns pulses tunable in 6.27µm-8.12µm with high-spatial-quality beam and the pulse energy of 0.9 mJ is demonstrated. The device exploits large-aperture PPRKTP MOPA for pumping ZGP OPO in a RISTRA cavity.

CF3B.5 • 14:45
High-Energy, Widely Tunable, Near- and Mid-Infrared Picosecond Optical Parametric Generator Based On CdSiP2, Suddapalli Chaitanya Kumar[1], M. Jelínek[3], Matthias Baudisch[1], K. T. Zawilski[4], Peter G. Schunemann[4], V. Kubecek[3], Jens Biegert[1,2], Majid Ebrahim-Zadeh[1,2]; *[1]NLO, ICFO-The Institute of Photonic Sciences, Spain; [2]Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain; [3]Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic; [4]BAE Systems, Inc, USA.* We report a high-energy picosecond optical-parametric-generator tunable over 6153-6732 nm in mid-IR,1264-1286 nm in near-IR, providing ~600 µJ of output energy over entire signal-tuning-range,>25µJ of idler energy over 55% of the idler-tuning-range.

CF3B.6 • 15:00
Broadband 6 µm OPA Driven by Yb:CaF2 DPSSL System, Giedrius Andriukaitis[1], Skirmantas Alisauskas[1], Audrius Pugzlys[1], Andrius Baltuska[1], Lihao Tan[2], Hua-Wei Jonathan Lim[2], Poh Boon Phua[2,3], Karolis Balskus[4], Andrejus Michailovas[4]; *[1]Photonics Institute, Vienna University of Technology, Austria; [2]DSO National Laboratories, Singapore; [3]Nanyang Technological University, Singapore; [4]EKSPLA Ltd., Lithuania.* 6-µJ, 6-µm pulses compressible to 1.5 optical cycles are generated in a multistage OPA driven by 500 Hz Yb:CaF2-DPSSL. The system is favorable for examination of λ-scaling laws of photoelectron wavepacket dynamics and for atmospheric sensing.

CF3B.7 • 15:15
Mid-IR Self-Compression to Few-Cycles in Bulk Material, Michael Hemmer[1], Matthias Baudisch[1], Alexandre Thai[1], Jens Biegert[1,2]; *[1]ICFO - The Institute of Photonics Sciences, Spain; [2]ICREA, Spain.* We report on the self-compression of 10-cycle mid-IR optical pulses to ~5 cycle duration at 3.1 µm center wavelength with up to 3 µJ energy in Yttrium Aluminum garnet (YAG).

CF3C • Precision Imaging and Sensing—Continued

CF3C.5 • 14:30
Direct optical phase retrieval from a three-dimensional interferometer, Heng Li[1], Frank W. Wise[2]; *[1]Physics Department, Cornell University, USA; [2]Department of Applied Physics, Cornell University, USA.* We report temporal phase retrieval from a three-dimensional interferometer, which measures the noncollinear first-order cross-correlation. This diagnostic can directly retrieve the temporal phase when transform-limited reference pulses are available.

CF3C.6 • 14:45
Multiple-Shell Ankylography, Leigh S. Martin[1,2], Chien-Chun Chen[1], Matthew D. Seaberg[2], Daniel E. Adams[2], Jianwei Miao[1]; *[1]Department of Physics and Astronomy, University of California at Los Angeles, USA; [2]Department of Physics and JILA, University of Colorado at Boulder, USA.* Ankylography is a newly developed technique for 3D imaging of small objects from a single view. Here we demonstrate that ankylography can in principle be extended to image larger 3D objects by incorporating multiple views.

CF3C.7 • 15:00
Sparsity-based single-shot subwavelength coherent diffractive imaging, Eliyahu Osherovich[1], Yoav Shechtman[2], Alexander Szameit[3], Pavel Sidorenko[2], Elad Bullkich[2], Snir Gazit[2], Shy Shoham[4], Ernst Bernhard Kley[3], Michael Zibulevsky[1], Irad Yavneh[1], Yonina C. Eldar[5], Oren Cohen[2], Mordechai Segev[2]; *[1]Computer Science, Technion, Israel; [2]Physics Department and Solid State Institute, Technion, Israel; [3]Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [4]Department of Biomedical Engineering, Technion, Israel; [5]Department of Electrical Engineering, Technion, Israel.* We present a sparsity-based method for subwavelength coherent diffractive imaging: an algorithmic approach for reconstruction of subwavelength images from a single intensity measurement of their far-field diffraction pattern.

CF3C.8 • 15:15
Reconstruction of tightly focused beams using Mie-scattering, Thomas Bauer[1,2], Sergej Orlov[1,2], Ulf Peschel[2,3], Peter Banzer[1,2], Gerd Leuchs[1,2]; *[1]Max Planck Institute for the Science of Light, Germany; [2]Institute for Optics, Information and Photonics, University of Erlangen-Nuremberg, Germany; [3]Cluster of Excellence "Engineering of Advanced Materials", Germany.* By using a subwavelength nano-particle as a field probe and a tailored detection scheme we are able to reconstruct the electric energy density in the focal plane of a high numerical aperture focusing system.

QF3D • Nano- and Near-Field Spectroscopy—Continued

QF3D.4 • 14:30
Tip-enhanced photoexpansion nano-spectroscopy using tunable quantum cascade lasers, Feng Lu[1], Mikhail A. Belkin[1]; *[1]Department of Electrical and Computer Engineering, The University of Texas at Austin, USA.* We report a novel mid-IR nano-spectroscopy technique. Absorption is detected by measuring associated sample expansion. High sensitivity and spatial resolution are obtained using local intensity enhancement below a metal atomic force microscope tip.

QF3D.5 • 14:45
Plasmonic Nano-protractor Based on Polarization Spectro-Tomography, Chihhui Wu[1], Farboe Shafiei[1], Elaine Li[1], Gennady Shvets[1]; *[1]Physics, UT Austin, USA.* We propose and experimentally realize a "plasmonic protractor": a spectroscopic device capable of detecting the orientation, position, and length of a small optically dark object using the polarization-resolved dark field microscopy.

QF3D.6 • 15:00
Coherent Nonlinear Spectroscopy with Spatio-temporally Controlled Fields, Felix Schlosser[1], Mario Schoth[1], Sven Burger[2], Frank Schmidt[2], Andreas Knorr[1], Shaul Mukamel[3], Marten Richter[1]; *[1]Institut für Theoretische Physik, Technische Universität Berlin, Germany; [2]Konrad-Zuse-Zentrum für Informationstechnik, Germany; [3]Department of Chemistry, University of California, USA.* Pulse shaping techniques combined with nanoplasmonics obtain spatiotemporal control of optical excitation in metal nanostructures. Using these methods we modify a coherent spectroscopy method to reveal new information about coupled nanosystems.

QF3D.7 • 15:15
Sub-diffraction-limited spatial resolution in CARS microscopy by ground state depletion, Carsten Cleff[1], Petra Gross[1], Carsten Fallnich[1], Herman L. Offerhaus[2], Jennifer L. Herek[2], Kai Kruse[3], Willem P. Beeker[3], Chris Lee[3], Klaus Boller[3]; *[1]Institute of Applied Physics, Westfälische Wilhelms-Universität Münster, Germany; [2]Optical Sciences Group, MESA+ Research Institute for Nanotechnology, University of Twente, Netherlands; [3]Laser Physics & Nonlinear Optics Group, MESA+ Research Institute for Nanotechnology, University of Twente, Netherlands.* Suppression of CARS signal generation is demonstrated via ground state depletion in a theoretical investigation. Using a donut-shaped control light field for population transfer results in sub-diffraction-limited spatial resolution CARS microscopy.

Room A5 | Room A6 | Room A7

CLEO: QELS-Fundamental Science

QF3E • Quantum Optics of Atoms and Solids—Continued

QF3E.5 • 14:30
The evidence of phase memory in induced coherence without induced emission, Axel Heuer[1], Sarah Fritsch[1], Ralf Menzel[1]; [1]*University of Potsdam, Germany.* The effect of phase memory allows to control the first order interference of two signal beams, generated by two simultaneously pumped parametric down converters, by the phase delay between the pump beams.

QF3E.6 • 14:45
Minimizing Random Disorder in a Kagome Lattice of Superconducting Resonators, Devin Underwood[1], Will Shanks[1], Jens Koch[2], Andrew Houck[1]; [1]*Electrical Engineering, Princeton University, USA;* [2]*Physics and Astronomy, Northwestern, USA.* To ultimately study phase transitions of light, arrays of superconducting resonators must be made with low disorder in individual resonator frequencies. We fabricate and measure such arrays, minimizing disorder to a few parts in 10^4.

QF3F • Entanglement—Continued

QF3F.5 • 14:30
Polarization-Entangled Photon Generation in a Standard Polarization-Maintaining Fiber, Bin Fang[1], Offir Cohen[1], Jamy Moreno[1], Virgina O. Lorenz[1]; [1]*Physics and Astronomy, University of Delaware, USA.* We demonstrate the generation of polarization-entangled photon pairs in a standard polarization-maintaining fiber using a Sagnac interferometer. This source's spatial mode is well matched to fiber-based quantum information networks.

QF3F.6 • 14:45
Impact of Cooling on Raman Scattering in a Chalcogenide (As_2S_3) Correlated Photon Pair Source, Matthew J. Collins[1], Alex S. Clark[1], Chunle Xiong[1], Eric C. Mägi[1], Benjamin J. Eggleton[1]; [1]*School of Physics, Centre for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), Institute of Photonics and Optical Science (IPOS),University of Sydney, Australia.* We show a reduction of spontaneous Raman scattering in chalcogenide at 77 K, which improves the photon statistics of correlated pair generation only in the frequency range close to the pump ($\Delta f < 3$ THz).

QF3F.7 • 15:00
Demonstration of non-monotonic quantum to classical transition in multiparticle interference, Young-Sik Ra[1], Malte C. Tichy[2,3], Hyang-Tag Lim[1], Osung Kwon[1], Florian Mintert[2,4], Andreas Buchleitner[2], Yoon-Ho Kim[1]; [1]*Physics, Pohang University of Science and Technology (POSTECH), Republic of Korea;* [2]*Physics, Albert-Ludwigs University of Freiburg, Germany;* [3]*Physics and Astronomy, University of Aarhus, Denmark;* [4]*Freiburg Institute for Advanced Studies, Albert-Ludwigs University of Freiburg, Germany.* We experimentally demonstrate the non-monotonic dependence of many-particle interference signals on the particles' mutual distinguishability. Such non-monotonicity is a generic feature of the quantum to classical transition in multiparticle systems.

QF3F.8 • 15:15
Experimental Implementation of an Approximate Partial Transpose for Two-Qubit Systems, Hyang-Tag Lim[1], Yong-Su Kim[1], Young-Sik Ra[1], Joonwoo Bae[2], Yoon-Ho Kim[1]; [1]*Physics, Pohang University of Science and Technology, Republic of Korea;* [2]*School of Computational Sciences, Korea Institute for Advanced Study, Republic of Korea.* We report the first experimental realization of an approximate partial transpose for two-qubit systems. Direct detection of entanglement, i.e., without performing quantum state tomography, using the partial transpose operation, is also demonstrated.

QF3G • Nonlinear Frequency Mixing Phenomena—Continued

QF3G.4 • 14:30
Second harmonic generation in aluminum nitride waveguides on silicon substrates, Chi Xiong[1], Wolfram Pernice[1], Carsten Schuck[1], Hong X. Tang[1]; [1]*Electrical Engineering, Yale University, USA.* Second harmonic generation is demonstrated in aluminum nitride (AlN) ridge waveguides on silicon substrates pumped by continuous wave telecom wavelength light. Phase matching is achieved by engineering waveguide modal dispersion.

QF3G.5 • 14:45
Phase Noise and Dispersion in integrated Silicon Nitride based Kerr-Comb generators, Johann Riemensberger[1], Klaus Hartinger[1,2], Tobias Herr[1], Emanuel Gavartin[1], Ronald Holzwarth[2,3], Tobias Kippenberg[1,3]; [1]*Ecole Polytechnique fédérale de Lausanne, Switzerland;* [2]*Menlo Systems GmbH, Germany;* [3]*Max-Planck-Institue for Quantum Optics, Germany.* We report on measurements of phase noise dynamics of microwave beat notes observed in low repetition rate silicon nitride based Kerr-comb generators and relate them to results from dispersion simulations and measurements.

QF3G.6 • 15:00
Continuous-Wave Frequency Conversion in Hydrogenated Amorphous Silicon Waveguides, Ke-Yao Wang[1], Amy Foster[1]; [1]*Electrical and Computer Engineering, Johns Hopkins University, USA.* We demonstrate nonlinear frequency conversion in hydrogenated amorphous silicon (a-Si:H) with conversion efficiency of -13dB at telecommunication data rates. Conversion bandwidths of 150nm are measured in CW regime at telecommunication wavelengths.

QF3G.7 • 15:15
Universal Dynamics of Kerr-Frequency Comb Formation in Microresonators, Tobias Herr[1], Klaus Hartinger[1,2], Johann Riemensberger[1], Christine Wang[2,3], Emanuel Gavartin[1], Ronald Holzwarth[2,3], Michael L. Gorodetsky[4], Tobias Kippenberg[1,3]; [1]*École Polytechnique Fédérale de Lausanne, Switzerland;*[2]*Menlo Systems GmbH, Germany;* [3]*Max-Planck-Institut für Quantenoptik, Germany;* [4]*Moscow State University, Russian Federation.* We experimentally investigate the initial dynamics of Kerr-frequency comb formation in crystalline MgF2 and planar Si3N4 microresonator and present a universal, platform independent condition for low phase noise performance.

Room A8

CLEO: QELS-Fundamental Science

QF3H • Photonic Crystals II—Continued

QF3H.5 • 14:30
Measuring the optical traversal time of a thick complex medium, Nathan Curry[1], Pierre Bondareff[1], Mathieu Leclercq[1], Niek Van Hulst[2,3], Riccardo Sapienza[2], Sylvain Gigan[1], Samuel Gresillon[1]; *[1]ESPCI PARISTECH, France; [2]ICFO, Spain; [3]ICREA, Spain.* We developed a technique to measure the temporal spread of a femtosecond optical pulse through a scattering medium, by means of speckle contrast. This technique is relevant for spatiotemporal control in complex media experiments.

QF3H.6 • 14:45
Enhanced light localization in modulated optical Bloch arrays, Ramy El-Ganainy[1], Mohammad-Ali Miri[2], Demetrios N. Christodoulides[2]; *[1]Department of physics, University of Toronto, Canada; [2]College of Optics & Photonics-CREOL, University of Central Florida, USA.* We study light propagation in disordered modulated Bloch arrays. For the specific system under consideration, our analysis predicts a 5 fold enhancement in light localization over that expected from a corresponding uniform lattice.

QF3H.7 • 15:00
Localized photonic band edge modes and orbital angular momenta of light in a golden-angle spiral, Seng Fatt Liew[1], Heeso Noh[1], Jacob Trevino[2], Luca Dal Negro[2,3], Hui Cao[1,4]; *[1]Department of Applied Physics, Yale University, USA; [2]Division of Materials Science and Engineering, Boston University, USA; [3]Department of Electrical and Computer Engineering & Photonics Center, Boston University, USA; [4]Department of Physics, Yale University, USA.* A golden-angle spiral lattice can posses an omni-directional photonic bandgap despite the lack of translational and rotational symmetries. We show that the band edge modes are spatially localized and possess discrete angular momenta.

QF3H.8 • 15:15
Dispersion in media containing resonant inclusions: where does it come from? Fabrice Lemoult[1], Mathias Fink[1], Geoffroy Lerosey[1]; *[1]Institut Langevin - ESPCI ParisTech & CNRS, France.* In this talk we demonstrate that a far field type of coupling involving Fano resonances can explain dispersion in media containing resonators. This generalizes various approaches such as metamaterials, hybridization band gaps and spoof plasmons.

Room B2 & B3

CLEO: Science & Innovations

CF3I • Space Division Multiplexing (SDM)—Continued

CF3I.4 • 14:30
Correction of Phase Distortion of an OAM Mode using GS Algorithm based Phase Retrieval, Yongxiong Ren[1], Hao Huang[1], Jeng-Yuan Yang[1], Yan Yan[1], Nisar Ahmed[1], Yang Yue[1], Alan Willner[1], Kevin Birnbaum[2], John Choi[2], Baris Erkmen[2], Sam Dolinar[2]; *[1]Department of Electrical Engineering, University of Southern California, USA; [2]Jet Propulsion Lab, USA.* The Gerchberg-Saxton algorithm based phase retrieval technique is used to correct the wavefront of distorted OAM modes. The simulation results show that this method can efficiently improve the mode purity of OAM modes up to 50%.

CF3I.5 • 14:45
Three-Dimensional Spherical Signal Constellation for Few-Mode Fiber based High-Speed Optical Transmission, Jianyong Zhang[3,1], Ivan B. Djordjevic[2]; *[1]Institute of lightwave technology, Beijing jiaotong univerisity, China; [2]Department of Electrical & Computer Engineering, University of Arizona, USA; [3]Key Lab of Alloptical Network & Advanced Telecommunication Network of EMC, Beijing Jiaotong University, China.* We propose the optimized three-dimensional spherical signal constellations (3D-SSCs) for few-mode fiber-optic communications. The results show that the 3D-SSCs outperform the previously proposed constellations and improve the OSNR by up to 3.89dB.

CF3I.6 • 15:00
Turbulence-Induced Crosstalk in Multiple-Spatial-Mode Optical Communication, Nivedita Chandrasekaran[1], Jeffrey H. Shapiro[1]; *[1]Research Laboratory of Electronics, Massachusetts Institute of Technology, USA.* Free-space optical communication at 10 bits/photon and 5 bits/sec-Hz requires hundreds to thousands of spatial modes. This paper compares turbulence-induced crosstalk for such systems using focused-beam, Hermite-Gaussian, or Laguerre-Gaussian modes.

Room C1 & C2

CF3J • Novel Materials and Approaches for "Green" Photonics—Continued

CF3J.4 • 14:30
Plasmonic metal nanoparticle enhanced thin film organic solar cells, Di Qu[1], Fang Liu[1], Yidong Huang[1], Wanlu Xie[1], Qi Xu[1], Youichi Aoki[2], Hiroki Tsujimura[2], Yoshiaki Oku[2]; *[1]Department of Electronic Engineering, Tsinghua University, China; [2]Interdisciplinary Devices R&D Center, Research and Development Headquarters, ROHM Co., Ltd., Japan.* A novel plasmonic enhanced OSCs with MNPs located at the interface of PEDOT:PSS anode layer and P3HT:PCBM active layer has been proposed and demonstrated theoretically and experimentally. The efficiency enhancement up to 25% is observed.

CF3J.5 • 14:45
Plasmonic gratings for enhanced light-trapping in thin-film organic solar cells, Khai Q. Le[1], Andrea Alù[1]; *[1]Electrical and Computer Engineering, The University of Texas at Austin, USA.* We discuss optimized silver gratings to enhance absorption in organic solar cells. The enhancement is attributed to generated surface plasmon (SP) polaritons and localized SP resonances, and to their optimized coupling over broad wavelength ranges.

CF3J.6 • 15:00
Design of Highly Absorption Structure by Flatted ITO Patterned Substrate for Thin Film a-Si Solar Cells, Hau-Vei Han[1], Huai-Shiang Shih[1], Hsin-Chu Chen[1], Yu-Lin Tsai[1], Peichen Yu[1], Hao-Chung Kuo[1]; *[1]Photonic & Institute of Electro-Optical Engineering, National Chiao Tung University, Taiwan.* The patterned substrate is a flatted structure which composed with two materials to enhance the absorption of a-Si solar cell. We optimized this structure by simulation method and find it has good omnidirectional antireflection effect.

CF3J.7 • 15:15
Heterogeneous Integration of III-V on Si: overcoming the lattice-mismatch barrier via the 1D route, Jae C. Shin[1], Parsian Mohseni[1], Stephanie Tomasulo[2], Kyle Montgomery[1], Minjoo Lee[2], Xiuling Li[1]; *[1]University of Illinois, USA; [2]Yale University, USA.* We demonstrate one-dimensional heteroepitaxy of InxGa1-xAs nanowires in the entire composition range on silicon substrates without dislocations. Doping and interfaces are characterized. Applications including solar cells will be presented.

Room C3 & C4

CF3K • ICLs and QCL Waveguide Design—Continued

CF3K.5 • 14:30
Quantum Cascade Lasers Employing a Wavelength-selective Asymmetric Mach-Zehnder Interferometer, Peter Q. Liu[1], Xiaojun Wang[2], Jen-Yu Fan[2], Claire Gmachl[1]; *[1]Princeton University, USA; [2]AdTech Optics, USA.* The idea of integrating an asymmetric Mach-Zehnder interferometer in Quantum Cascade laser cavities to introduce mode selectivity is proposed and analyzed. Preliminary results show narrowing of the laser spectra with such cavities.

CF3K.6 • 14:45
Surface Plasmon Mode Coupling to the Insulator/Metal Interface of Sloped Sidewalls of Wet-etched Quantum Cascade Lasers, Xue Huang[1], Yenting Chiu[1], William Charles[1,2], Claire Gmachl[1]; *[1]Princeton University, USA; [2]Phononic Devices. Inc., USA.* We find the main challenge for narrowing wet-etched ridges of long-wavelength Quantum Cascade lasers is surface plasmon mode coupling at the insulator/metal interface of sloped sidewalls, resulting in extra waveguide loss and hence high threshold.

CF3K.7 • 15:00
Substrate Emission of Ring Cavity Surface Emitting Quantum Cascade Lasers, Clemens Schwarzer[1], Elvis Mujagic[1], Werner Schrenk[1], Jianxin Chen[2], Claire Gmachl[2], Gottfried Strasser[1]; *[1]Inst. for Solid State Electronics, Vienna Univ. of Technology, Austria; [2]Department of Electrical Engineering, Princeton University, USA.* We report studies on bidirectional emission of ring cavity surface emitting quantum cascade lasers. Special attention is put on substrate emission and methods for favoring one single emission direction.

CF3K.8 • 15:15
Frequency-Domain Model of Longitudinal Mode Interaction in Semiconductor Ring Lasers, Xinlun Cai[1], Gabor Mezosi[2], Ying-Lung Daniel Ho[1], Marc Sorel[2], Siyuan Yu[1]; *[1]Department of Electrical and Electronic Engineering, University of Bristol, United Kingdom; [2]Department of Electrical and Electronic Engineering, University of Glasgow, United Kingdom.* A frequency-domain model for semiconductor ring lasers (SRLs) is presented. Every aspect of the lasing characteristics of SRLs can be reproduced. Several SRLs are fabricated and tested. Good agreement between theory and experiment is demonstrated.

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Salon I & II

Marriott San Jose
Salon III

Marriott San Jose
Salon IV

CLEO: Science & Innovations

CF3L • Ultrafast Mode-locking Dynamics—Continued

CF3L.5 • 14:30 Invited
Vector Soliton Control by Saturable Absorbers with Complex Recovery, Oleg G. Okhotnikov[1], Regina Gumenyuk[1]; *[1]Optoelectronics Research Centre, Finland.* Saturable absorbers exhibiting complex recovery are shown to affect strongly the dynamics of vector soliton interaction. The study demonstrates that soliton bunch can be compressed by attractive forces generated by a saturable absorber.

CF3L.6 • 15:00
Intracavity self-generated 2π pulses and coherent population trapping in a mode-locked laser, Koji Masuda[1,2], Ladan Arissian[2,3], Jean-Claude Diels[1,2]; *[1]Department of Physics, University of New Mexico, USA; [2]CHTM, University of New Mexico, USA; [3]Department of Computer and Electrical Engineering, University of New Mexico, USA.* 2π pulse self-induced transparency in rubidium is reported for the first time inside a mode-locked laser cavity. Simultaneous occurrence of a dark line repetition rate resonance is observed in the 87Rb vapor cell.

CF3L.7 • 15:15
In-band Pumped Nd:LuVO4 Laser Mode-locked by Negative χ(2)-lens Formation in an Intracavity LBO Crystal, Hristo Iliev[1], Veselin Aleksandrov[1], Ivan C. Buchvarov[1], Zhang Huaijin[2], Jiyang Wang[2], Junhai Liu[3], Valentin Petrov[4]; *[1]Physiscs Department, Sofia University, Bulgaria; [2]National Laboratory of Crystal Materials, Shandong University, China; [3]College of Physics,, Qingdao University, China; [4]Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy, Germany.* Self-starting χ(2)-lens mode-locking of an in-band pumped, Nd:LuVO4 laser using second harmonic generation in LBO is demonstrated. Pulses as short as 4.7 ps and average powers reaching 3.1 W at 110 MHz are achieved.

CF3M • Nonlinear Optics in Nanophotonic Structures III—Continued

CF3M.4 • 14:30
Stable Dual Mode High Repetition Rate Mode-Locked Laser Based on an Integrated Nonlinear Microring Resonator, Marco Peccianti[2,1], Alessia Pasquazi[2], Brent Little[3], Sai T. Chu[3], David J. Moss[4], Roberto Morandotti[2]; *[1]UOS Montelibretti, Institute for Complex Systems - CNR, Italy; [2]Ultrafast Optical Processing Group, INRS-EMT, Canada; [3]Infinera Ltd, USA; [4]CUDOS and IPOS, Australia.* We demonstrate a mode locked laser based on a integrated high-Q microring resonator that exhibits stable operation of two slightly shifted spectral optical comb replicas, generating a highly monochromatic radiofrequency modulation.

CF3M.5 • 14:45
Electrically Controlled Silicon Nitride Ring Resonator for Quasi-phase Matched Second-harmonic Generation, Rafael Euzebio P. de Oliveira[1], Michal Lipson[2], Christiano J. S. de Matos[1]; *[1]Grupo de Fotônica, Universidade Presbiteriana Mackenzie / MACKPESQUISA, São Paulo, SP, Brazil; [2]Cornell Nanophotonics Group, Cornell University, USA.* We propose and simulate an electro-optical ring resonator for second-harmonic generation that is controlled by a dc field. Results predict -24.3dB conversion efficiency without need for external compensation of nonlinearity-induced resonance shift.

CF3M.6 • 15:00
Guided Bloch Surface Wave polaritons: a route towards polariton circuits., Marco Liscidini[1], Dario Gerace[1], Daniele Sanvitto[3], Daniele Bajoni[2]; *[1]Physics, University of Pavia, Italy; [2]Electronics, University of Pavia, Italy; [3]Istituto di Nanoscienze, CNR, Italy.* We report on the strong coupling between a single quantum-well and guided Bloch Surface Waves. This results in a guided polariton that may serve as a component for the realization of "polaritonic integrated circuits".

CF3M.7 • 15:15
Proposal of two-input, phase-switched, all-optical flip flops, Brian A. Daniel[1], Govind P. Agrawal[1]; *[1]The Institute of Optics, University of Rochester, USA.* We propose using two input beams to a bistable Kerr resonator for overcoming the thermal limitation to the switching speed between stable states. We theoretically demonstrate flip-flop operation by phase modulations of the inputs.

CF3N • Fiber DFB's and Nonlinear Effects—Continued

CF3N.4 • 14:30
Distributed Feedback Fiber Laser Employing Brillouin Gain, Kazi S. Abedin[1], Paul S. Westbrook[1], Jeffrey W. Nicholson[1], Jerome Porque[1], Tristan Kremp[1], Xiaoping Liu[1]; *[1]OFS Laboratories, USA.* A single frequency distributed feedback Brillouin fiber laser exhibiting a threshold of 30 mW, and pump-to-Stokes conversion efficiency of 27% is shown. The Brillouin laser operates over a pump frequency detuning range exceeding 1 GHz.

CF3N.5 • 14:45
Twisted Hi-Bi Fiber DFB Lasers with Controllable Output Polarization, Michalis N. Zervas[1,2], Louise Walker[2], Richard Wilmshurst[2]; *[1]University of Southampton, Optoelectronics Research Centre, United Kingdom; [2]SPI Lasers, United Kingdom.* Externally applied birefringence-axis twist is shown to provide accurate control of the output SOP in hibi fiber DFB lasers. Continuous tuning from circular to linear polarization, with PER of ~40dB has been demonstrated.

CF3N.6 • 15:00
Single-frequency Raman Distributed-feedback Fiber Laser, Jindan Shi[1], Shaif-ul Alam[1], Morten Ibsen[1]; *[1]Optoelectronics Research Centre, University of Southampton, United Kingdom.* We report a 30cm-long Raman Distributed-feedback laser with ~450mW threshold in a commercial Ge/Si fiber. The laser is pumped with up to 1.3W-CW at 1064nm and exhibits single-frequency performance with a linewidth <2.5kHz at 1109.5nm.

CF3N.7 • 15:15
Watt-level fluoride glass Raman fiber laserm Vincent Fortin[1], Martin Bernier[1], Dominic Faucher[1], Julien Carrier[1], Réal Vallée[1]; *[1]Center for Optics, Photonics, and Lasers (COPL), Université Laval, Canada.* We report on the first watt-level fluoride glass Raman fiber laser. A maximum output power of 1.22 W at the first Stokes order wavelength of 2231.4 nm was produced out of a nested cavity Raman fiber laser.