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CENTRO DE INVESTIGACIONES
EN ÓPTICA, A.C.

Siegman
International
**School
on Lasers**

Co-founded by IPG Photonics

AUGUST 6-11, 2017

Leon, Mexico at CIO



August 2017

Dear Siegman International School on Lasers participant,

We warmly welcome you to the 2017 OSA Foundation Siegman International School on Lasers. This fourth Siegman School is hosted by the Centro de Investigaciones en Óptica (CIO), located in León, Guanajuato, Mexico.

At CIO we will receive nearly 100 students from 28 different countries, who will learn on the most recent advancements on lasers and its applications, from academia and industry leaders in the field and as well as professional development workshops. We hereby acknowledge our 2017 faculty, who will stay at CIO the whole week to interact with the attendees:

- Anna Bezryadina, University of California San Diego, USA.
- Mercedeh Khajavikhan, University of Central Florida, USA.
- Donna Strickland, University of Waterloo, Canada.
- Judith Su, University of Arizona, USA.
- Katarina Svanberg, Lund Laser Centre, Sweden.
- Michael J. Damzen, Imperial College London, UK.
- Jean-luc Doumont, Principia, USA.
- Liang Feng, State University of New York at Buffalo, USA.
- Andrew Forbes, University of Witwatersrand, South Africa.
- Roberto Morandotti, Institut National de la Recherche Scientifique, Canada.
- Luis A. Orozco, University of Maryland, USA.

The school will consist of lectures that will range from a deep revision on the lasers pulses compression techniques, to the construction of tunable lasers for remote and airborne sensing. On-chip quantum frequency combs, microtoroid resonators, metallic nanolasers and orbital angular momentum microlasers will also be reviewed; as well as the lasers applications to single molecules detection, bacteria trapping and manipulation, the fundamental study of the atomic quantum structure, and diseases detection.

CIO is not only honored to host the Siegman International School on Laser 2017, but also happy to open its doors to the students and lecturers, who will be able to meet the CIO faculty, alumni and facilities, and form friendships and professional relationships for the future. We acknowledge the OSA Foundation and IPG Photonics for choosing CIO as the 2017 host; as well as to all the sponsors and donors for making this fourth school possible. We wish all of the attendees a fruitful, inspiring and happy week; enjoying not only the technical lectures, but also the rich cultural and social activities, which will offer a sample of the prehispanic and colonial heritages of Mexico, the typical mariachi music and the worldwide recognized favors of the Mexican cuisine.

¡Bienvenidos a México amigos!

The CIO Local Program Committee:

Eric Rosas (Chairman), Vicente Aboites, Enrique Castro, Elder de la Rosa, Annette Torres, Eleonor León, Samantha Salinas, Javier Omedes

Siegman International School on Lasers

Agenda

Sunday, 6 August

9:00–18:30	Registration
18:30–19:30	Welcome Reception

Monday, 7 August

10:00–11:00	Opening Ceremony
11:00–11:15	Coffee Break
11:15–12:15	Luis A. Orozco , University of Maryland, USA <i>Lasers Applications to the Study of the Atomic Quantum Structure</i>
12:15–13:15	Michael J. Damzen , Imperial College London, United Kingdom <i>Space Lasers: Wavelength Tunable Lasers for Space and Airborne Remote Sensing</i>
13:15–14:15	Lunch
14:15–16:15	Katarina Svanberg , Lund Laser Centre, Sweden <i>Laser Light Disease Detection</i>
16:15–16:30	Coffee Break
16:30–18:30	CIO Labs Tour
18:30–19:30	Shoe Painting Contest

Siegman International School on Lasers

Agenda

Tuesday, 8 August

9:00–10:00	Donna Strickland , University of Waterloo <i>Canada Laser Pulses Compression Techniques</i>
10:00–11:00	Luis A. Orozco , University of Maryland, USA <i>Lasers Applications to the Study of the Atomic Quantum Structure</i>
11:00–11:15	Coffee Break
11:15–12:15	Liang Feng , State University of New York at Buffalo, USA <i>Quantum Inspired Photonics</i>
12:15–13:15	Michael J. Damzen , Imperial College London, United Kingdom <i>Space Lasers: Wavelength Tunable Lasers for Space and Airborne Remote Sensing</i>
13:15–14:15	Lunch
14:15–15:15	Mercedeh Khajavikhan , University of Central Florida, USA <i>Coherent Properties of Metallic Nanolasers</i>
15:15–16:15	School Photograph and OSAF Presentation
16:15–16:30	Coffee Break
16:30–18:30	Posters Session 1
18:30–20:30	León Downtown Walking Tour

Siegman International School on Lasers

Agenda

Wednesday, 9 August

9:00–10:00	Donna Strickland , University of Waterloo <i>Canada Laser Pulses Compression Techniques</i>
10:00–11:00	Luis A. Orozco , University of Maryland, USA <i>Lasers Applications to the Study of the Atomic Quantum Structure</i>
11:00–11:15	Coffee Break
11:15–13:15	Jean-luc Doumont , Principae, Belgium <i>Structuring Your Research Paper</i>
13:15–14:15	Lunch
14:15–15:15	Andrew Forbes , University of Witwatersrand, South Africa <i>Classical And Quantum Properties of Vector Vortex Light Fields</i>
15:15–16:15	Roberto Morandotti , Institut National de la Recherche Scientifique, Canada <i>On-Chip Quantum Frequency Combs</i>
16:15–16:30	Coffee Break
16:30–18:30	Jean-luc Doumont , Principae, Belgium <i>Making The Most of Your Presentation</i>
19:30–21:30	School Dinner

Siegman International School on Lasers

Agenda

Thursday, 10 August

9:00–10:00	Anna S. Bezryadina , University of California San Diego, USA <i>Optical Tweezers Applications in the Bacteria Trapping and Manipulation</i>
10:00–11:00	Luis A. Orozco , University of Maryland, USA <i>Lasers Applications to the Study of the Atomic Quantum Structure</i>
11:00–11:15	Coffee Break
11:15–12:15	Judith Su , University of Arizona, USA <i>Single Molecule Detection with Microtoroid Resonators</i>
12:15–13:15	Michael J. Damzen , Imperial College London, United Kingdom <i>A Commercial Story: Midaz Lasers Ltd., from Research to Product to Exit</i>
13:15–14:15	Lunch
14:15–15:15	Andrew Forbes , University of Witwatersrand, South Africa <i>Classical and Quantum Properties of Vector Vortex Light Fields</i>
15:15–16:15	Roberto Morandotti , Institut National de la Recherche Scientifique, Canada <i>On-Chip Quantum Frequency Combs</i>
16:15–16:30	Coffee Break
16:30–18:30	Posters Session 2
18:30–21:30	Guanajuato Walking Tour with Student Music & Wine Dinner on your own in Guanajuato

Siegman International School on Lasers

Agenda

Friday, 11 August

9:00–10:00	Anna S. Bezryadina , University of California San Diego, USA <i>Optical Tweezers Applications in the Bacteria Trapping and Manipulation</i>
10:00–11:00	Luis A. Orozco , University of Maryland, USA <i>Lasers Applications to the Study of the Atomic Quantum Structure</i>
11:00–11:15	Coffee Break
11:15–12:15	Closing Ceremony
12:15–19:30	Tequila Distillery and Archaeological Site Tour
19:30–21:30	Closing Reception

Speaker Bios & Abstracts



Dr. Anna Bezryadina is a postdoctoral scientist at University of California San Diego (UCSD). She has wide ranging experience in optics and photonics, her research interests include bio-photonics, optical trapping and manipulation for biological applications, and high-resolution microscopy. In 2005 she finished her B.S. degree in Physics and Applied Mathematics from San Francisco State University (SFSU), where she worked for several years on optical solitons, photonic lattices and vortices. Then she joined the University of California Santa Cruz to investigate the reliability and degradation mechanisms in different types of solar cells. Dr. Bezryadina did her research at the NASA Ames Research Center,

built photothermal deflection spectrometer to measure mid-gap trap density in thin films and analyzed the degradation mechanisms of silicon, polymers, and nanoparticle thin films. After receiving her Ph.D. in 2012, she returned back to photonics and experimental optics with biological applications. She joined Zhigang Chen's lab at SFSU where she developed new optical trapping and manipulation tools to study microorganisms' interactions, as well as demonstrating biological waveguides for the first time. In 2015 she moved to UCSD for her current position as a postdoctoral scientist in the Liu's lab to develop video-speed super-resolution plasmonic structure illumination microscopy to study biological processes at 50nm scale.

Applications of Optical Tweezers in Bacterial Trapping and Manipulation

TIME: Thursday, 9:00 and Friday, 9:00

The first lecture will provide introduction to optical tweezers and how it used in biology and medicine. Optical tweezers can provide accurate control and manipulation of objects from 10nm to over 100 μ m. It also allows detection of tiny displacement and forces in the range of 0.1 - 100 acting on trapped objects. To create more versatile optical tweezers system scientists use computer generated holograms, which can easily form multiple traps and which can be used interactively. However, if you want to apply this great tool to trap living cells and organisms, you need to take an account experimental restrictions and limitations of lasers. We will look at how light and matter interact and how certain wavelengths can cause photo damage and affect living cells' behavior.

The second lecture will focus on new and amazing research directions in the trapping and manipulation of bacteria and other microorganisms. I will introduce several applications of optical tweezers which revolutionize medicine: subcellular manipulation, DNA manipulation, detecting cancer cells, bacteria-drug interaction and more. Finally, I will describe my recent experimental research on developing tug-of-war optical tweezers to study rod-shaped and asymmetrically shaped bacteria and how it helps to investigate biofilm formation and antibiotic resistance.

Speaker Bios & Abstracts



Professor Michael Damzen is Professor of Experimental Laser Physics at Imperial College London, consistently ranked as one of the top-10 Universities in the World. He is Head of the Photonics Group whose research activities including laser technology, applied optics, biomedical imaging, biophotonics, and industrial photonics applications. He is the author of over 170 publications in refereed journals, 250 Conference presentations including 40 invited talks, 8 books or book chapters, and 6 patents in the area of lasers and nonlinear optics. He is an elected Fellow of the Optical Society of America (OSA) and an elected Fellow of the Institute of Physics (IoP) in the UK.

He has developed a number of novel high power laser architectures, technology and techniques. He currently leads a programme on the development of lasers and instrumentation applied to space and airborne atmospheric and vegetation remote sensing including for the European Space Agency (ESA). This work utilises breakthrough development of broadly wavelength-tunable diode-pumped Alexandrite laser technology operating in short pulse, high pulse rate mode. The tunable laser technology is also being configured for compact, low-cost application in biophotonics. He is Academic Founder of Midaz Lasers Ltd, and acted as Director and Chief Scientific Officer over its operational period from 2006 to its trade sale to premier scientific laser company Coherent Lasers in 2012. Midaz designed, assembled and sold engineered laser and amplifier products to the precision laser manufacturing market, incorporating patented solid-state laser technology arising from his research.

Space Lasers: Wavelength Tunable Lasers for Space and Airborne Remote Sensing

TIME: Monday, 12:15 and Tuesday, 12:15

Amongst its many capabilities, lasers have the ability to reach out to great distances and transmit or acquire information. This presentation overviews laser-based remote sensing: current applications and laser technology status. In particular I will describe how satellite-based remote sensing using lasers provides valuable global monitoring of atmospheric and climate change processes, trace gases, weather prediction and altimetry for ground surface mapping and vegetation canopy height. The laser requirements for space operation, however, are shown to be quite severe.

I will describe our own development and operation of pulsed diode-pumped Alexandrite laser towards the first tunable wavelength space laser (~ 700 – 850nm), and its unique potential for combined 3-D spatial and spectroscopic mapping of Earth and atmosphere, and in particular for monitoring vegetation (e.g. agriculture/crops and forestry). I will give examples of applications we are addressing for the European Space Agency for satellite-based remote sensing and some developments of the laser technology towards more commercial operation on airborne and unmanned drone platforms Whilst our new diode-pumped Alexandrite laser technology has been initially focused on remote sensing, I will give examples of dual use of the tunable Alexandrite for other potential applications including biophotonics and quantum technologies.

A Commercial Story: Midaz Lasers Ltd from Research to Product to Exit

TIME: Thursday, 12:15

I will recount the story of Spin-Out Company, Midaz Laser Ltd, I founded in 2006, from its beginnings in our laser research laboratory, operation for 6 years then its successful trade sale in 2012. Midaz Laser Ltd was a Spin-Out Company Ltd from Imperial College London, and arose as the vehicle for commercial exploitation of patented micro-slab laser technology arising from research in our laser group. Midaz designed, assembled and sold engineered laser and amplifier products incorporating this patented technology. The principal market was for its application was in precision laser manufacturing. It made a successful trade sale exit to premier scientific laser company, Coherent Lasers, in 2012.

Speaker Bios & Abstracts



After his PhD in optics under the supervision of Tony Siegman at Stanford University, **Jean-luc Doumont** decided to devote his life to training researchers in communication and other career-critical skills. An articulate, entertaining and thought-provoking speaker, he is acclaimed worldwide for his no-nonsense approach, his highly applicable, often life-changing recommendations on a wide range of topics, and *Trees, maps, and theorems*, his book about “effective communication for rational minds.” For additional information, visit www.principiae.be.

Structuring Your Research Paper

TIME: Wednesday, 11:15

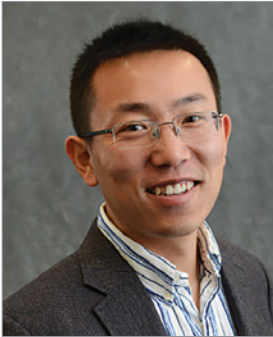
Papers are one of the few deliverables of a researcher’s work. A well designed paper is not only more likely to be published, read, and cited, it also allows each reader to select only what he or she needs to read. This lecture shows how to structure research papers, dissertations, and other reports effectively at all levels to get the readers’ attention, facilitate navigation, and thus get the message across optimally to their audiences.

Making the Most of Your Presentation

TIME: Wednesday, 16:30

Strong presentation skills are a key to success for engineers, scientists, and others, yet many speakers are at a loss to tackle the task. Systematic as they otherwise can be in their work, they go at it intuitively or haphazardly, with much good will but seldom good results. In this talk, Dr Doumont proposes a systematic way to prepare and deliver an oral presentation: he covers structure, slides, and delivery, as well as stage fright.

Speaker Bios & Abstracts



Liang Feng is an Assistant Professor of Electrical Engineering at the State University of New York at Buffalo (SUNY Buffalo). He received his Ph.D. in Electrical Engineering from UCSD in 2010, and was subsequently a postdoc researcher in the Department of Electrical Engineering at California Institute of Technology and the NSF Nanoscale Science and Technology Center at UC Berkeley. In January 2014, he joined the faculty at SUNY Buffalo. He has authored and coauthored more than 50 papers in a variety of journals including Science, Nature Materials, Nature Photonics and PRL. His current research is supported by National Science Foundation, Army Research Office, Department of Energy, and King Abdullah University of Science and Technology. He is a recipient of the U.S. Army Research Office Young Investigator Program (YIP) Award in 2016.

Quantum Inspired Photonics

TIME: Tuesday, 11:15

Quantum mechanics, dealing with atoms and electrons on a single-particle level, is the basis of modern technologies in computing and communication. While photonics is considered a completely different research subject, its intrinsic capability of creating non-Hermitian Hamiltonians by optical gain and loss makes it an ideal platform to explore various quantum symmetry paradigms that were deemed impossible in the past. In this seminar, I will present our recent efforts on the quantum inspired photonic materials where quantum symmetries (such as parity-time symmetry) guide the design of photonic materials for unprecedented optical properties. Although it was widely believed that optical loss is detrimental in photonic materials, I will start from an opposite viewpoint and develop a new paradigm of positively manipulating optical losses, demonstrating unidirectional light-matter interaction tailored at a “quantum” exceptional point in the complex dielectric permittivity domain. Moreover, I will discuss harnessing optical losses to enable novel laser materials for unique microlaser functionality. In particular, I will focus on an orbital angular momentum (OAM) microlaser that structures and twists the lasing radiation at the microscale, which is expected to address the growing demand for information capacity. These quantum explorations not only provide positive impacts on fundamental quantum physics but also facilitate technological breakthroughs in photonic materials. Hence, researches in quantum inspired photonic materials of such two-fold benefits are advancing both fields simultaneously.

Speaker Bios & Abstracts



Andrew Forbes received his PhD (1998) from the University of Natal (South Africa), and subsequently spent several years working as an applied laser physicist, first for the South African Atomic Energy Corporation and then later in a private laser company where he was Technical Director. In 2004 he joined the CSIR National Laser Centre where he was Chief Researcher and Research Group Leader of the Mathematical Optics group. In March 2015 Andrew joined the U. Witwatersrand on the Distinguished Professor programme and has established a new laboratory for Structured Light. Andrew chairs or serves on the committees of several international conferences, OSA and SPIE committees, and serves

on the editorial board of three optics journals. He has published more than 300 scientific papers, several patents, and has delivered more than 60 invited talks internationally. He is active in promoting photonics in South Africa, a founding member of the Photonics Initiative of South Africa, a Fellow of both SPIE and the OSA, and an elected member of the Academy of Science of South Africa. In 2015 Andrew won a national award for his contribution to photonics in Africa. Andrew spends his time having fun with the taxpayers' money, continuing his love affair with laser beams and resonators, digital holography, orbital angular momentum and quantum optics.

Classical and Quantum Properties of Vector Vortex Light Fields

TIME: Wednesday, 14:15 and Thursday, 14:15

Spin-orbit states of light, as described by the higher-order Poincare sphere, have found many applications of late, both classical and quantum. Controversially, such classical states have been referred to as "classically entangled", mimicking some quantum properties by virtue of their non-separability in spatial mode and polarisation. In part I of this talk I will outline how to create, propagate and detect such states of classical light. I will cover how to create them on-demand directly from the source, how to detect them in a deterministic manner without photon loss, and how to propagate them in free-space and in optical fibre. In part II I will show how their non-separability can be used to define new laser beam quality factors for such beams, blurring the quantum-classical divide, and also to realise hybrid classical-quantum processes that exploit the best of both worlds.

Speaker Bios & Abstracts



Mercedeh Khajavikhan received her Ph.D. in Electrical Engineering from the University of Minnesota in 2009. Her dissertation was on coherent beam combining for high power laser applications. In 2009, she joined the University of California in San Diego as a postdoctoral researcher where she worked on the design and development of nanolasers, plasmonic devices, and silicon photonics components. Since August 2012, she is an assistant professor in the College of Optics and Photonics (CREOL) at the University of Central Florida, working primarily on novel phenomena in active photonic platforms. She received the NSF Early CAREER Award in 2015 and the ONR Young Investigator Award in 2016.

Coherent Properties of Metallic Nanolasers

TIME: Tuesday, 14:15

Nanolasers, a family of light sources with dimensions smaller than the wavelength of light are one of the latest additions to the laser family. The application of such sources ranges from on-chip optical communication to high-resolution and high-throughput imaging, sensing and spectroscopy. This has fueled interest in developing the 'ultimate' nanolaser: a scalable, low-threshold source of radiation that operates at room temperature and occupies a small volume on a chip. However, progress towards realizing this ultimate nano-laser has been hindered by the lack of a systematic approach to scaling down the size of the laser cavity without significantly increasing the threshold power required for lasing. In other words, the miniaturization of laser resonators using dielectric or metallic structures, across all previously proposed solutions, faces two challenges; First, the (eigen) mode scalability, implying the existence of a self-sustained electromagnetic field regardless of the cavity size. Second, the disproportionate reduction of optical gain and cavity losses, which results in a large and/or unattainable lasing threshold as the volume of the resonator is reduced. In this talk, I present our results about lasing in the newly introduced nanoscale, sub-wavelength in all three dimensions, coaxial cavities that potentially solve the resonator scalability challenge by the choice of geometry and metal composition. In particular, I present the design, fabrication, characterization, and analysis that resulted in the smallest, room-temperature, continuous wave, telecommunication wavelength laser to date. Furthermore, by utilizing the unique properties of the coaxial cavities, which may have a single non-degenerate mode, I discuss the possibility of thresholdless lasing that provides a scalable solution to overcome the metal losses. I will then explain how to measure the second order coherence function for such light sources in order to verify if they are indeed capable of generating coherent radiation. At the end, I will discuss the possibility of collective behaviors in arrays of nanoscale lasers.

Speaker Bios & Abstracts



Roberto Morandotti received his M.Sc. in 1993 from the University of Genoa (Italy) and his Ph.D. in 1999 from the University of Glasgow (United Kingdom). Since 2008, he is Full Professor at Institut National de la Recherche Scientifique, Centre Énergie Matériaux Télécommunication (INRS-EMT), which he joined in 2003. Additionally, he is Adjunct Professor in the Institute of Fundamental and Frontier Science (IFFS at UESTC, Chengdu, China) and at ITMO (St. Petersburg, Russia).

Prof. Morandotti has a broad experience in the field of photonics, ranging from the fabrication of integrated devices for nonlinear and quantum optics to the use of state-of-the-art optical characterization techniques in the Infrared and Terahertz frequency domains. His achievements are well documented by his production in terms of publications in the most prestigious scientific journals (i.e. Science, Nature Photonics, Nature Communications, Science Advances, Physical Review Letters, etc.)

The impact of his research to the scientific community has been further recognized by multiple prestigious awards. In 2011, he was bestowed the NSERC E.W.R. Steacie Memorial Fellowship (the most prestigious Canadian award for early career scientists). In 2016, he has been awarded a Canada Research Chair Tier 1 in Smart Photonics. He is Fellow of the Royal Society of Canada, the American Physical Society, the Optical Society of America, the SPIE, and the Institute of Physics (UK). He was the Program Chair and General Chair of CLEO/QELS 2014 and 2016, respectively, a conference which is considered by many as the most important in photonics.

On-Chip Quantum Frequency Combs

TIME: Wednesday, 15:15 and Thursday, 15:15

We demonstrate that integrated frequency combs (on-chip light sources with a broad spectrum of evenly-spaced frequency modes) based on high-Q nonlinear microring resonators can provide solutions for scalable complex quantum state generation. By using spontaneous four-wave mixing within the resonators, we demonstrate the generation of bi- and multi-photon entangled qubit states over a broad comb of channels, and the generation of entangled high-dimensional (quDit) states, where the photons are created in a coherent superposition of multiple pure frequency modes. Furthermore, using off-the-shelf telecommunications components, we introduce a practical platform for the coherent manipulation and control of frequency-entangled quDit states.

Speaker Bios & Abstracts



Luis Adolfo Orozco was born in Guadalajara, Mexico in 1958. He completed his engineering studies at the Instituto Tecnológico y de Estudios Superiores de Occidente in Guadalajara, Mexico and his postgraduate studies at the University of Texas at Austin, obtaining his doctorate in 1987. He held a postdoctoral position at Harvard, passing part of this one at CERN, Switzerland. He returned to the United States and worked from 1991 to 2003 as a professor in the physics department of the State University of New York at Stony Brook. Since 2003, he is a professor of physics at the University of Maryland in College Park, MD, USA, where he is co-director of the Physics Frontier Center of the Joint Quantum

Institute. Throughout his career Dr. Orozco has been Guggenheim Fellow (1998), Fellow of the American Physical Society (2000) Fellow of the Optical Society of America (2003), Fellow of the Institute of Physics, UK (2005), Distinguished Traveling Lecturer of the American Physical Society (2002-2017) and corresponding member of the Academia Mexicana de Ciencias since (2005). He has an Honoris Causa Doctorate from INAOE, Mexico (2016). He has graduated 23 PhD students and more than 60 undergraduates have worked in his group. Together with his students and collaborators he is author of more than 100 publications. As a researcher, he is interested in quantum optics, quantum information, fundamental symmetry tests, and high precision spectroscopy.

Laser Applications to the Study of Atomic Quantum Structure

TIME: Monday, 11:15, Tuesday, 10:00, Wednesday, 10:00, Thursday, 10:00 and Friday, 10:00

This series of five lectures includes 1st lecture: Introduction to the interaction of laser light with atoms, in its simplest form. We will develop tools to quantify the strength of the interaction. 2nd lecture: We will work out the atom-light interaction in the idealized case of a two level atom introducing the idea of Rabi oscillations. 3rd lecture: Different types of laser traps for atoms: The dipole trap, the magneto optical trap (MOT) and the dipole traps near waveguide nanostructures. 4th and 5th lecture: We will then look in some detail at the atomic quantum structure and what it means. How to measure those properties and evaluate signal to noise and signal to background ratios. We will focus on studies of atomic quantum properties of francium and rubidium that reveal both electronic and nuclear characteristics, making these and other atoms ideal playgrounds for weak interaction studies.

Speaker Bios & Abstracts



Donna Strickland received her B. Eng. from McMaster University and her PhD from the University of Rochester. Along with her PhD supervisor, Dr. Gerard Mourou, Donna Strickland co-invented Chirped Pulse Amplification. Dr. Strickland was a research associate at the National Research Council of Canada, a physicist at Lawrence Livermore National Laboratory and a member of technical staff at Princeton University. Dr. Strickland joined the physics department of the University of Waterloo in 1997. At Waterloo, Dr. Strickland's ultrafast laser group develops high-intensity laser systems for nonlinear optics investigations. She is a recipient of a Sloan Research Fellowship, a Premier's Research Excellence Award, a Cottrell Scholars Award and is a Fellow of the Optical Society of America. She served as the 2013 OSA president.

Basic Pulse Compression Techniques

TIME: Tuesday, 9:00

Material dispersion leads to short laser pulses stretching in time. Sometimes this stretching is unwanted and sometimes it is used in applications such as Chirped Pulse Amplification. In either case, to regain the short pulse duration, the pulse stretching can be compensated with dispersion lines having the opposite sign of group velocity dispersion (GVD). In 1969, Edmond Treacy showed that a pair of parallel gratings delivers negative group-velocity dispersion. Gratings offer large dispersion, but for ultrashort pulses, it was found in 1984 that prism pairs could also offer sufficient negative group velocity dispersion needed to offset some material dispersion. Sometimes you want the grating dispersion line to have positive dispersion. Oscar Martinez realized that a pair of anti-parallel gratings with a telescope in between the gratings could give both positive, negative or zero dispersion.

In this 1-hour lecture, we will go over the concept of group velocity dispersion and see how material dispersion leads to pulse broadening and then how angular dispersion from gratings and prisms lead to pulse compression.

Higher Order Dispersion Compensation

TIME: Wednesday, 9:00

For the shortest pulses, the material dispersion of optical systems leads to uncompensated chirps due to the higher order GVD terms, if using simple grating or prism pulse compressors. The first improvement in higher order dispersion compensation was the use of a grating stretcher, which could ideally be matched with a grating compressor to all orders of dispersion. The next improvement in grating stretchers came when it was realized that aberrations of the optical telescope in the grating stretcher could lead to unwanted dispersion. The simple 1:1 telescope was replaced with an Offner triplet. To better compensate higher order terms, pulse-shaping techniques are used. These include 4-f, zero-dispersion grating lines with pulse shaping devices, such as, liquid crystal displays[5], AO modulators and deformable mirrors, placed in the Fourier plane of the 4-f system. Pierre Tournais realized that AO modulation can also be used directly to eliminate unwanted dispersion.

In this lecture we will discuss eliminating the higher order dispersion terms to yield the shortest, nearly transform limited pulse durations.

Speaker Bios & Abstracts



Judith Su is an Assistant Professor in Biomedical Engineering and an Assistant Professor of Optical Sciences at the University of Arizona. She is also an Associate Member of the University of Arizona Cancer Center. Judith received her B.S. and M.S. from MIT in Mechanical Engineering and her Ph.D. from Caltech in Biochemistry & Molecular Biophysics. Her background is in imaging, microfabrication, and optical instrument building for biological and medical applications. In general, her research interests are to develop new imaging, sensing, and rheological techniques to reveal basic biological functions at the molecular, cellular, and tissue levels. Recently her work has centered on label-

free single molecule detection using microtoroid optical resonators with a focus on basic research, and translational medicine through the development of miniature field portable devices.

Single Molecule Detection with Microtoroid Resonators

TIME: Thursday, 11:15

Label-free single molecule detection has been a long-standing goal of bioengineers and physicists. The main obstacle in the detection of single molecules, however, is to sufficiently decrease the noise level of the measurements such that a single molecule can be distinguished from background fluctuations. We have used laser frequency locking in combination with balanced detection and data processing techniques to improve the signal-to-noise ratio of microtoroid optical resonators and report the detection of a wide range of nanoscale objects including nanoparticles with radii from 100 to 2.5 nm, exosomes, ribosomes, and single protein molecules (mouse immunoglobulin G and human interleukin-2). We further extend the exosome results toward the creation of a minimally-invasive tumor biopsy assay. Our results agree with established model predictions for the frequency shift of the resonator upon particle binding across several orders of magnitude of particle radius (100 nm to 2 nm). We anticipate that our results will enable many applications, including more sensitive medical diagnostics and fundamental studies of single receptor-ligand and protein-protein interactions in real time. Future research thrusts will also be discussed.

Speaker Bios & Abstracts



Katarina Svanberg is an M.D. and a Ph.D and holds a professorship in Oncology at Lund University, Sweden as well as at South China Normal University in Guangzhou, China. She started her research career by studying laser light interaction in biological tissue and is among the early clinical researchers in biomedical optics and photonics for medical applications. Her PhD thesis in Medical Science presented preclinical research work within experimental photodynamic therapy and tissue spectroscopy. The post doc research activity was focussed on clinical applications of the preclinical achievements. Katarina Svanberg has combined her clinical activity with research work and thus

been able to introduce a new cancer treatment modality in Oncology (Photodynamic Therapy) at the Lund University Hospital. She has been a key person in the collaboration in between several clinics and departments at Lund University in introducing and applying laser-induced fluorescence spectroscopy for early tumour detection. Katarina Svanberg has also been involved in developing a new method for gas monitoring; Gas in Scattering Media Absorption Spectroscopy (GASMAS) in the human body and this technique has been applied in the diagnosis of sinusitis. GASMAS also seems promising for in situ real time surveillance of preterm babies controlling their lung function. She has been active in transferring spectroscopic biomedical techniques to the third world and has also been involved in clinical work in Africa. Katarina Svanberg has coauthored more than 150 peer reviewed papers and contributed with book chapters in the field and also organized many international conferences in Biomedical Optics. She is a board member of the Lund Laser Centre and since 1993 she has served as the director of the Lund University Medical Laser Centre, where she now is the chair of the Board. Katarina Svanberg is a board member at the UNESCO International Centre for Theoretical Physics (ICTP) in Trieste, Italy and has been a member in many international advisory committees including at FDA and NIH in the US. She was a member of the steering committee for the UNESCO proclaimed Year of Light 2015. During the period 2005-2008 she was a director at large of the Board of the International Society for Optics and Photonics (SPIE) and during the period 2009-2012 in the presidential chain of the society where she served as the President of SPIE in 2011. She is a fellow of SPIE and of the Electromagnetic Research Society (PIERS). She was awarded the National Institute of Health (NIH) Lifetime Achievement Award in Biophotonics for Pioneering Work 2015 and the SPIE Gold Medal 2017.

Applications of Laser Spectroscopy to Meet Challenges in Medicine

TIME: Monday, 14:15

Laser based spectroscopic techniques can be used in the detection and therapy of human diseases. Examples from oncology, ortopedics and pediatrics as well as from the field of food quality control will be given.

Laser spectroscopy has been shown to be a valuable tool both in the detection and the therapy of human malignancies. The most important prognostic factor for cancer patients is early tumour discovery. If malignant tumours are detected during the non-invasive stage, most tumours show a high cure rate of more than 90 %. Even though there are many conventional diagnostic modalities, very early tumours may

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be difficult to discover. Laser-induced fluorescence (LIF) for tissue characterisation is a technique that can be used for monitoring the biomolecular changes in tissue under transformation from normal to dysplastic and cancer tissue before structural tissue changes are seen at a later stage. The technique is based on UV or near-UV illumination for fluorescence excitation. The fluorescence from endogenous chromophores in the tissue alone, or enhanced by exogenously administered tumour seeking substances can be utilised. The technique is non-invasive and gives the results in real-time. LIF can be applied for point monitoring or in an imaging mode for larger areas, such as the vocal cords or the portio of the cervical area.

Photodynamic therapy is a selective treatment technique for human malignancies. To overcome the limited light penetration in superficial illumination interstitial delivery (IPDT) with the light transmitted to the tumour via optical fibres has been developed. Interactive feed-back dosimetry is of importance for optimising this modality and such a concept has been developed. The technique has special interest for tumours where there are no other options, such as for recurrent prostate cancer after ionising radiation. For correct dosimetry it is important to assess the optical properties of tissue; this can be done by time resolving propagation techniques.

Another technique which has been developed for medical application is based on gas in scattering media absorption spectroscopy (GASMAS). The technique is used to detect free gas (oxygen and water vapour) in hollow organs in the human body and has been applied to the detection of the human sinus cavities. The GASMAS technique might also be used for surveillance of prematurely born infants. Approximately 10-15% of all deliveries in Europe and in the US are preterm. As the organs are not fully developed there is a risk of morbidities. In particular the lung function is limited and the babies may develop respiratory distress symptom resulting in decreased oxygen saturation affecting risk organs, such as the brain. GASMAS may also be developed for detection of some very common infections, such as in the middle ear and in the human sinuses in the facial skeleton. These diseases are examples of infections where antibiotics have been overused due to the fact that the majority of these conditions are viral infections and no antibiotics should be prescribed. However, due to the misuse of antibiotics first and second line antibiotics are not effective anymore in e.g. middle ear infection occurring in China and a serious example on how antibiotic resistance easily can be induced. GASMAS has a potential to discriminate the origin of the disease and thus guide in the decision of appropriate therapy. Such aspects are presently pursued at SCNU, Guangzhou. Another interesting indication for GASMAS, most probably in combination with Laser Doppler Imaging, is the detection of caput necrosis in the hip, where we have shown promising initial results in vitro

Many of these techniques can also be applied to study other organic material, e.g. food. As an example studies have been performed on fruit maturing combining the techniques of fluorescence, reflectance and GASMAS. Another interesting field in the food area is to follow packed and sealed food and monitor the aging process going on after the production date of many different food articles.

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P1 • Ana Luisa Aguayo Alvarado • Centro de Investigaciones en Óptica, A.C.

SPDC analysis by using high efficient vectorial Bessel beams

The construction of vectorial Bessel beams is presented for use as pumping in the process of SPDC and the analysis of the Angular Spectrum (AS) of such a process. The generation of vector beams is of great interest for many applications such as optical tweezers, propagation through turbulent mediums, and processes that require a strong focus of the beams. It has been generated efficient Bessel-Gauss beams that own orbital angular momentum (OAM) and spin angular momentum (SAM) by using a Sagnac interferometer, the polarization is given by a Quarter Wave Plate and the optical vortex by using a vortex phase plate that gives to the beams the opposite topological charge of ± 1 . It is presented the analysis of the OAM (by means of a triangular aperture) and the SAM (by using a linear polarizer). After the process of SPDC is achieved in a second order nonlinear crystal, the angular spectrum is observed and analyzed by using an iCCD camera.

P2 • Danylo Babich • L'Institut des Matériaux Jean Rouxel de Nantes

Electro-optically induced Mott transition in GaTa₄Se₈ compound

After decades of intense developments, silicon based microelectronics is facing severe problems related to the ultimate limit of miniaturization. A possible alternative consists in using new materials based on new paradigms. In this context, using electronic transition such as the Mott insulator to metal transition appears as an appealing solution. Mott insulators are a class of compounds, which should be metallic according to conventional band theories, but are actually insulators due to Coulombian repulsion. In these compounds, a new way to induce insulator to metal transitions was recently unveiled: the application of electric field. The associated microscopic mechanism could imply the multiplication of free carriers in the conduction band (CB). Interestingly, laser pulse could also promote carriers in the CB due to photoexcitation process. In this poster, I will present preliminary results based on the combined application of electrical and laser pulses on the Mott insulator GaTa₄Se₈.

P3 • Leo Bahr • Friedrich-Alexander-Universität Erlangen-Nürnberg, GER

Online determination of the polymorphic modification of crystalline nanoparticles dispersed in the gas-phase by Raman spectroscopy

Crystallinity as an internal structural parameter is of great importance for the application properties of nanoparticles. With our contribution we show how Raman spectroscopy can be applied for the determination of these polymorphic modifications online and in situ during the production process. Distinction of different crystal structures via Raman spectroscopy is based on the excitation of various phonon modes in the crystal lattice. In detail, our presentation describes the NIR-Raman measurement setup we built up as well as a measurement chamber, in which defined nanoparticles can be dispersed in various gases (air, N₂, CO₂) and spectroscopically analyzed. As example particle systems we used TiO₂, ZrO₂ and Fe₂O₃. The acquired spectra were compared to reference spectra taken from non-dispersed nanoparticle powder. The temperature of the continuous phase medium (different gases) was evaluated likewise by the same Raman setup.

P4 • Ma Soledad Billion Reyes • Universidad Autonoma de san Luis Potosí

Design of an optical cavity with a flat top beam

Atomic interferometry is a well known method to perform precision measurements of accelerations. We want to enhance the interferometric signal by adding an optical cavity around the free-falling atoms inside

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of a vacuum chamber. We use a ring configuration to support a traveling wave and avoid spatial fluctuations in the light shift. To induce collective behavior (entangled state), we design the optical cavity with a cooperativity factor higher than one. We present the optical cavity with a maximized beam waist to reach homogeneous illumination of the atomic cloud. The mirrors have high reflectivity ($R=99.999\%$) at 780 nm, in a non-confocal arrangement and we pursue to excite transverse modes independently or simultaneously. We describe our progress to achieve a transverse mode closer to a flat-top, by adding 2 LG modes.

P5 • Valeriia Bobkova • Bauman Moscow State Technical University

Pulse repetition rate stabilization of a femtosecond fiber laser by the second harmonic of methane optical frequency standards

The accurate frequencies of the methane molecular transitions have been widely used in laser stabilization. As a result, an optical frequency standard on the basis of the 3.39- μ m He-Ne laser was designed. A solid-state cw Cr²⁺:ZnSe laser has been used for Doppler-free spectroscopy of methane vibrational-rotational $\nu_1 + \nu_4$ band lines for the purpose of study prospects for use in laser frequency stabilization. Next, several approaches for optical frequency combs' stabilization were proposed and significant efforts were directed toward the study of mode-locked fiber laser-based optical frequency combs to extend the stable optical frequency to other optical or radio-frequency spectral domains. In this paper, we report the method of a pulse repetition rate stabilization of a femtosecond Er-doped fiber laser by the second harmonic of methane optical frequency standards. As a masters sources for a frequency doubling, we used He-Ne and Cr²⁺:ZnSe lasers, which were correspondingly phase-locked to frequency-stabilized lasers by methane cell.

P6 • Emma Celina Brambila-Tamayo • Instituto de Física-UNAM

Self-collimated beam interaction in a metallic nanocolloid

The high nonlinear optical response of nanocolloids makes these media very appealing in terms of applications. Recently, they have become more popular thanks to the development of new techniques to synthesize nanoparticles with different materials that modify their nonlinearity. An interesting application of nanoparticle suspensions is the formation of bright optical spatial solitons. Due to plasmonic resonances and its interplay with optical forces, metallic colloids allow soliton formation with larger propagation distances and less power than in dielectric colloids. Moreover, these media present a much faster response than liquid crystals and photorefractives. In this work, we measured the nonlinear time response in a metallic nanosuspension and the important parameters to generate self-collimated beams were characterized. We also studied the incoherent interaction between two solitons as a function of their input angles by analyzing their output angle, width and polarization.

P7 • Sara Bucht • University of Rochester/Laboratory for Laser Energetics

Transforming the idler from a non-collinear OPCPA system to a high-fidelity laser

The idler is an existing byproduct created by all optical parametric chirped-pulse-amplification (OPCPA) systems with similar bandwidth and energy to the signal. Since idlers are red-shifted compared to their signals, they have been proposed as a high power laser to access NIR-MIR wavelengths that are otherwise inaccessible by standard gain medium. With proper preparation, the idler can be transformed to a high-fidelity laser pulse from an already existing OPCPA system. Two issues arising in the optical parametric amplifier, angular dispersion and complicated chirp reversal have historically made using the idler difficult to use and have never been simultaneously solved in a single system. A two-prism angular dispersion

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compensator and a grism stretcher show promising analytic solutions to these two problems without significantly sacrificing energy or bandwidth.

P8 • Jing Cao • Université Paris-Sud

Femtosecond laser-induced nanoscale phase separation in lithium niobium silicate glass

We investigate the femtosecond (fs) laser-induced crystallization of lithium niobium silicate glass. We demonstrate a nanoscale phase separation whereby LiNbO₃ crystals are embedded in lamella-shaped frames of amorphous SiO₂. In addition, this self-organized nanostructure may successfully explain the origin of the laser-induced birefringence in this multicomponent glass quite different from pure silica. The obtained nanostructure may have applications in fabricating second order nonlinear optical devices.

P9 • Jaime Julio Cervera Moreno • Universidad de Guanajuato

Sizing of Nanoparticles for Quantum Dots Applications using Differential Dynamic Microscopy

We present results of the application of Differential Dynamic Microscopy (DDM) to determine the size of biocompatible nanoparticles. For the acquisition of image series, conventional bright field and fluorescence contrasts were used, as well as different objective magnifications to cover a broad range of scattering vectors q . The results are compared to Dynamic Light scattering (DLS) methods. We show that DDM is a reliable and inexpensive technique to characterize nanoparticle systems, even in the case of fluorescently labeled particles, for which traditional particle sizing methods like DLS cannot be applied.

P10 • Ravikumar Chinnarasu • National Tsing Hua University

Electromagnetically-induced-transparency-based narrowband entangled photon generation using 2D Rb-87 magneto-optical trap

Entangled photons with narrow bandwidth and long coherence time are necessary for quantum information applications. They can be generated by using Four wave mixing (FWM) in atomic cloud. However, the atoms may highly absorb the generated anti-stokes photons. This can be avoided by utilizing the coherence effect called electromagnetically induced transparency. In our experiment, we use a 2D MOT system that is different from the conventional 3D MOT system. Specially designed with two pairs of anti-Helmholtz coils, it allows atoms to be efficiently trapped along the longitudinal axis. Moreover, its large interacting volume provides high optical depths easily. Other than that, with zero magnetic field gradient along the quantization axis, it can highly reduce the de-coherence effects and help to increase the atomic coherences (EIT). We have observed EIT in a 2D Rb-87 magneto-optical trap with a length of 1.2 cm. Our system with EIT feature gives an efficient platform to store photons as well, which is one of our goals too.

P11 • Cheikh Amadou Bamba Dath • Université Cheikh Anta Diop (UCAD), Dakar

Wireless optical signal availability and link range analyses over strong fluctuating meteorological conditions

Objectives: Free-Space Optics (FSO) can provide high data rate, up to 10 Gbps. The performances of FSO systems are generally affected by weather conditions. In that paper we establish percentages of availabilities, the power margins and optimal link ranges of some FSO systems, for different strong meteorological conditions in Senegal.

Methods/Statistical analysis: Received signal and availability of FSO links are subject to link distance and meteorological conditions like, clear atmosphere, rain, and sandstorm or in presence of heavy dust. In

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this paper we investigate the effects of weather conditions on the performance of FSO links, taking the climate of Senegal as a case study. However, the effect of turbulence induced irradiance fluctuation, varying beam divergence angle and misalignment conditions, and their impacts on the performances of the FSO systems were analyzed and estimated. Based on visibilities data recorded from 2003 to 2014, particular FSO link optimization's simulation cases were analyzed, in terms of power margin, availability and maximum distance. The results were performed by a lognormal distribution with good precision of the tests of correlations.

Findings: range and availability of optical link for different weather conditions are established easily and with high precision. As there is no known study on the effects of weather conditions in this country, this paper offers an attempt to analyze and identify the challenges related to the deployment and optimization of FSO systems under Senegalese's weather.

Application/Improvements: For more flexibility, we forecast using an application programming interface to make easy use of the modeling approach by professional and academic actors. We plan to extend the study in all the cities in Senegal and for the Sahel region.

P12 • Juan Samuel Sebastián Durán Gómez • Universidad de Guanajuato

Design, Manufacture and Characterization of Optical Waveguides with Femtosecond Laser Direct Write for Integrated Quantum Photonic Circuits

We present the advances in the fabrication of optical buried waveguides in water white glass slide using the method of Femtosecond Laser Direct-Write (FLDW) and the characterization of size and efficiency of the waveguides. We also present the manufacture and characterization of two waveguides coupled by evanescent fields. We measure the coupling coefficient for different distance between pairs of waveguides by End Fire Coupling Method using a CCD camera for measure the relative intensities. Also we create another dispositives with more complexity; lattices of linear waveguides with interactions by evanescent fields, power splitter with one hundred micrometers between the outputs ports and directional couplers with the same distance between the outpt ports. With this technique we can create integrated optical devices in three dimensions that we will implement with photons produced by Spontaneous Parametric Down Conversion for Quantum Information like quantum logical gates.

P13 • Citlali Eliosa Minor • CICESE

Mirrorless optical parametric oscillators in periodically poled lithium niobate and tantalate

The conditions to obtain mirrorless optical parametric oscillation of counter-propagating waves in PPLN and PPLT are analyzed. We consider experimental limitations such as damage fluence, absorption, pump depletion from third-order nonlinear interactions as well as the feasibility of creating domain structures with the required periodicity, of the order of a few microns, and the tolerance to domain width fluctuations.

By numerically solving the spatio-temporal coupled wave equations we find that pulses of $\sim 0.7 - 2$ ns minimize the pump energy required for mirrorless oscillation to rise from quantum noise to a detectable level. We conclude that fifth-order quasi-phase-matched mirrorless oscillation, which requires poling periodicities of $\sim 5.3 \mu\text{m}$, is possible in PPLN provided that high quality, ~ 2 cm long samples are used, as well as short (~ 1 ns) pump pulses of ~ 160 J. Due to its lower nonlinearity, in PPLT is only feasible if third-order quasi-phase-matching is used.

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P14 • Mohamed Essawy • Higher Technological Institute (HTI)

LIBS analysis of adsorbed Cu and Co ions with Artificial Neural Network Interpretation

Toxic heavy metals pollution; particularly in the aquatic environment, poses serious environmental problems due to the rapid industrial development. Fish bones were used as sorbents of low cost and high adsorption capacity to remove heavy metals (Cu and Co) from wastewater. In this study, sorption process exhibits a function of initial metal concentration, contact time and pH. Laser-induced breakdown spectroscopy (LIBS) has been utilized to detect the adsorbed heavy metals in the fish bones qualitatively. LIBS results have been validated experimentally by those obtained from X-Ray Fluorescence spectrometry (XRF), which verified the feasibility of using LIBS to detect traces of Cu and Co ions. In addition, (Artificial Neural Network; ANN); as one of the artificial intelligence techniques; has been applied to investigate the effects of all conducted parameters. It provides with LIBS a complementary and simultaneous mathematical model capable to efficiently simulate and predict the adsorption of Cu^{2+} and Co^{2+} with less time and effort.

P15 • Maria Angela Faustino • University of the Philippines

Terahertz emission enhancement in semi-insulating gallium arsenide integrated with subwavelength one-dimensional metal line array

A one-order-of-magnitude terahertz (THz) emission enhancement in the transmission geometry, over a 0.7-THz broadband range, was observed in semi-insulating gallium arsenide (SI-GaAs) integrated with a subwavelength onedimensional metal line array (1DMLA). THz emission of the 1DMLA samples showed an intensity increase and exhibited a full-width-at-half-maximum broadening relative to the emission of the bare substrate. Improved index matching could not account for the observed phenomenon. A nonlinear dependence of the integrated THz emission intensity on the number of illuminated lines and on the pump power was observed. The actual origin of the increased THz emission is still under investigation. At present, it is attributed to extraordinary optical transmission.

P16 • Angelina Frank • The University of Tokyo

Dual-Comb Two-Photon Tomography

In the presented work on Dual-Comb Two-Photon Tomography, a dual-comb system with gigahertz repetition rates in a counter-propagating beam geometry is utilized to interrogate a sample for its two-photon absorption, where depending on the repetition rates and their defined offset microsecond temporal resolution for millimeter sample space can be achieved. The difference in repetition rates of the two frequency combs enables scanning of the sample without the necessity for continuous mechanical changes of the setup. If a sample is present at the point of comb superposition, attenuation of the superimposed combs will occur due to absorption. The therefore varying temporal intensity profile of the detected pulses can be directly converted into the spatial distribution of the sample, if the refractive index of the sample is known. Applications of ultrafast dual-comb tomography lie in any field concerned with spatially-resolved, ultrafast measurements in volumes requiring high penetration depth with examples including a.o. the study of gas diffusion, hydrogel and cell-signaling dynamics and their spatially selective photochemistry.

P17 • Rahul Gangwar • Indian Institute of Technology (Indian School of Mines) Dhanbad

Refractive Index Sensor based Dual core Photonic Crystal Fiber with selectively liquid infiltration in the central hole

We present a refractive index sensor based on liquid infiltrated dual core photonic crystal fiber (PCF). By

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omitting two air holes near the center of the fiber we create two fiber cores and the center hole is filled with the analyte liquids. By using mode coupling theory, its sensing performances have been studied numerically. The results show that the refractive index sensor with 1 cm length PCF has a very high sensitivity of -24774.19 nm/RIU .

P18 • Oana Grigore • National Institute for Laser, Plasma and Radiation Physics

High intensity THz pulses generation from various plasma filaments

THz radiation encountered many technological challenges in terms of emission efficiency and detection sensitivity. There are many types of THz sources and the most common and intense THz sources are laser based sources due to the high development of femtosecond lasers. Until now, the laser based sources use a Gaussian-type laser beam, regardless of the generation method. THz generation from plasma filaments is an intensely studied method. Using this method one could obtain THz pulse energies up to 10 microJ. In order to rise the THz pulse energy, two multiple THz pulses generation methods were developed by our group. These methods show that the intensity saturation threshold of the plasma filament produced by a single infrared pulse could be overcome and high energy THz pulses could be obtained. Using other types of beams, such as Bessel \tilde{n} type laser beams, make THz sources different by electron distribution in plasma and could improve the generation of THz radiation. Using a Bessel beam the efficiency conversion infrared \tilde{n} THz radiation was increased by one order of magnitude in comparison with the configuration with a Gaussian type laser beam.

P19 • Yousuf Hemani • University of Eastern Finland, Joensuu & Center for free electron laser science, Hamburg

Near Infrared Ultrafast Pulse Shaping and Temporal Characterization for Optical-Waveform Synthesizer

The aim of my Master's Thesis project was to implement a flexible dispersion management in the near infrared channel of a high energy, high power, few cycle, optical parametric waveform synthesizer. Coherent optical pulse synthesis of high-energy, few-cycle pulses is one of the most promising methods to efficiently generate isolated extreme ultraviolet (XUV) and soft X-ray attosecond pulses through HHG, because of the flexibility in spectral shaping and scalability in spectral bandwidth as well as energy. The system comprises of two-octave, passively CEP-stable, two-channel OPAs driven by sub-picosecond pulses from an Yb-based multi-mJ regenerative amplifier. The OPAs are seeded by a passively CEP-stable front-end based on white-light supercontinuum generation in bulk. The dispersion management is implemented using a Dazzler and to go towards high energy OPCAs and achieve characterization of the pulse using FROG, a multi-pass cryogenic amplifier is implemented for pumping.

P20 • James Hendrie • University of New Mexico

Resonant Dispersion and Intracavity Phase Interferometry

Frequency combs generated by highly stabilized mode-locked lasers are used for spectroscopy and phase sensing. We generate a dual frequency comb with a single un-stabilized laser, and demonstrate a phase detection resolution outperforming the most sophisticated stabilized laser. The 2 frequency combs are correlated, and when interfered, beat at a frequency $\Delta\nu$ with a phase noise 1000000 smaller than that of the individual combs. $\Delta\nu$ is the relative phase shift between the two intracavity pulses, divided by the cavity round-trip time τ . A demonstrated phase sensitivity of 0.00000001 (in elongation: the diameter of a proton)

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can be modified by making τ frequency dependent through a giant dispersion which has to be applied to each mode of the comb. We obtain this result with an etalon inserted in the laser, which locks the modes of the comb. The laser outputs two "nested" frequency combs, with tooth spacing in the GHz and MHz range, locked in a fixed ratio. The phase response is seen to be reduced by a factor of 3 because of the positive dispersion of the etalon in transmission. An etalon in reflection (Gires-Tournois) is expected to yield a 1000 larger frequency response $\Delta\nu$.

P21 • Mohammad Jobayer Hossain • CREOL, University of Central Florida

Single Mode Orbital Angular Momentum Nanolasers

Light's carrying linear momentum was a known fact for centuries. The radiation pressure due to linear momentum was successfully utilized in solar-sail propulsion of spacecraft and laser cooling. It was only in 1992 when Allen et. al. discovered that light can carry Orbital Angular Momentum (OAM) as well. Since then, OAM has always been considered a thriving area for its potential use in imaging, optical manipulation, optical communication etc. Over the last 25 years the optics community has seen several effective ways of ensuring twisted phase front. These include spiral phase plate, $\lambda/2$ converter, Q-plates, spatial light modulator etc. However, integrated photonic links requires on-chip implementation of OAM lasers. In my poster presentation, I am going to talk about an array of nanolasers which can act together as a single mode OAM laser.

P22 • Ning Hsu • University of New Mexico

A Complete Temporal Ultrashort Pulse Characterization System by Applying Cascading Second-Order Nonlinearity Inside a Spectrometer

We are developing a compact, transportable instrument that can characterize ultra-short laser pulses including all spatial, temporal, spectral, and phase properties on a pulse-by-pulse basis. This rugged instrument will be based on a novel concept of extremely compact spectrometer incorporating two nonlinear crystal for complete field characterization. It is known that temporal amplitude-phase reconstruction can be achieved with a single shot autocorrelation, and two spectra (for the fundamental and second harmonic). The diagnostic instrument is considerably simplified if the spectral phase information is extracted from the spectrometer or interferometer. It is shown here that this is possible by cascaded nonlinearity between the fundamental and the second harmonic inside the spectrometer.

P23 • Arkadiusz Hudzikowski • Wroclaw University of Science and Technolgy

Compact Intracavity QEPAS sensor using a high-finesse cavity and 5.2 μm CW Quantum Cascade Laser for Nitric Oxide detection

Intracavity quartz-enhanced photoacoustic spectroscopy using a room-temperature, continuous-wave, distributed-feedback quantum cascade laser (QCL) emitting at 5.263 μm (1900.08 cm^{-1}) was reported. We developed a new compact, high-finesse, bow-tie optical cavity with an integrated quartz tuning fork (QTF) and piezoelectric transducer (PZT). The optimum configuration of the bow-tie cavity was simulated using custom software. Measurements were performed with a wavelength modulation scheme (WM) using a 2f detection procedure for nitric oxide (NO) detection. A detection limit of 4.8 ppbv within a 30 ms integration time was achieved.

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P24 • Zeferino Ibarra • Centro de Investigaciones en Óptica

Photon pairs sources for quantum optical coherence tomography

We have implemented two different configurations of Quantum Optical Coherence Tomography (QOCT) using a photon pair generated by SPDC type I and type II, one of them using the most popular two-photon interferometric setup: the Hong-Ou-Mandel interferometer (HOM). The HOM interferogram graphs the coincidences of SPDC photons versus their optical path difference, showing a non coincidences detection, this phenomenon is called HOM dip. A-scan of a biological sample would comprise a collection of coincidence-rate minima occurring whenever the path length in the delay arm matches that of a reflecting surface in the sample. The other configuration used a quantum version of Michelson interferometer (MI). The experimental implementation of an IM has the advantage of being simpler than that of HOM and, likewise, it is feasible to implement this configuration for QOCT applications. Axial resolutions were reached around 4 microns for both interferometers."

P25 • Timothy Oshiobughie Imogore • Friedrich-Schiller-Universität, Jena, Germany

Automated alignment of coherently combined high power lasers "Due to the desire to mitigate power related limitations of individual amplifiers and achieve high power lasers for ambitious scientific and industrial applications, powerful ultrafast fiber lasers rely on coherent beam combination. In this case, output beams from many separate laser channels are interfered constructively. To achieve optimal performance, the individual amplifiers need to be aligned perfectly in space. Manual alignment is impractical for large number of amplifier channels hence the need for automated alignment based on active feed back stabilization. In my research work and master's thesis, a laser with two coherently combined amplifiers and a respective control system is being built to demonstrate automatized operation and the fidelity of the automatic optimization will be evaluated and optimized. Scalability to many amplifier channels will also be investigated theoretically."

P26 • Hemang Jani • University of Alabama in Huntsville

Ultrafast Nanophotonics: Quantum Dot Thin-Film Sensor Fabrication and Few-Cycle Pump-Probe Spectroscopy

Ultrafast optics and nanophotonics have been two active frontiers in optics over the last 20 years. Recently, interest has grown rapidly toward the juncture of the two fields, ultrafast nanophotonics, where the combination of spatial exciton confinement and ultrafast excitation leads to many interesting new phenomena and applications. Here we report our ongoing effort to study carrier-envelope phase (CEP) sensitive effects in semiconductor quantum dots (QDs). The work is divided into two parts. In sensor fabrication, we have explored deposition of II-VI colloidal QD thin films with both sol-gel glass and photoresist polymer (e.g., SU-8) as the host matrix. In particular, the acid-free sol-gel fabrication of CdSe QD thin films proves to be a fast and low-cost path towards QD optical sensors with good mechanical and thermal stabilities. Meanwhile, we have developed a few-cycle pump-probe system and have used it to study the ultrafast carrier dynamics in layered structures such as AlGaAs/GaAs photo-cathodes and GaAs epi-wafers. These preparations pave the way for our eventual goal of studying ultrafast dynamics in semiconductor QDs.

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P27 • James Jena • National University of Science and Technology

Supercontinuum Generation in Highly Birefringent PCFs

We have simulated the propagation of femtosecond laser pulses in birefringent photonic crystal fibers to understand the supercontinuum generation spectral broadening process. The dynamics involved were analysed through the variation of pulse properties and fiber parameters. Photonic crystal fibers possess elevated nonlinearity to the extent that laser pulses of lower energy than was previously required, can now be used for supercontinuum generation in coherent white light sources. Coherent white light is crucial for use in optical coherence tomography, microscopy and spectroscopy applications whose relevance extend to materials processing and the medical field. A variety of pulse energies were used in each simulation where 80 fs pulses at 800 nm pump wavelength were launched into a 30 cm, all-normal dispersion low birefringence photonic crystal fiber. Several supercontinuum spectra whose bandwidths cover the visible range were observed for different simulation conditions. The effects of varying pulse duration, average pump power and fiber dispersion on the broadening of the spectrum were investigated and the dynamics analysed. Self-phase modulation (SPM) and Raman scattering were identified among the nonlinear effects responsible for the spectral broadening in the normal dispersion regime. It was observed that at 568 mW a continuum span of 327 nm was achieved, hence higher average pump powers resulted in a broader spectral continuum whilst a narrower spectra were observed with lower pump powers. Our simulations showed that for short pump pulses of duration below 100 fs, spectral broadening was concluded within 0.025 m of propagation and SPM was the dominant nonlinear effect coupled with stimulated Raman scattering (SRS). Optical wave breaking (OWB) was significant with pulse duration above 150 fs. Self-steepening was observed to accelerate the completion of spectral broadening in the ANDi PCF. Spectral broadening could not be observed when nonlinear effects were not coupled with dispersion. Conclusively, normal dispersion and nonlinearity complement each other to result in extreme broadening whereas anomalous dispersion counteracts with nonlinearity leading to soliton formation and more efficient broadening from soliton fission. Spectra spanning 400 nm and 192 nm were obtained in the anomalous and normal dispersion regimes respectively when pump pulses with 150 mW average power and 50 fs duration at 800 nm wavelength were used. In the 30 cm long, highly birefringent fiber whose beat length was 0.68 μm , pulses launched with either vertical or horizontal polarisation showed neither decoupling nor change in state of polarisation. The slow axis had greater dispersion and generated wider spectra than the fast axis. When pumping with polarised light at an angle to the vertical axis, mode coupling from cross phase modulation was observed resulting in the state of polarisation changing periodically every beat length during propagation. The state of polarisation of output spectra was sensitive to small variations in fiber length. Simulations agreed well with experiments and results in literature.

P28 • Maribel Juárez Hernández • Centro de Investigaciones en Óptica, A.C.

Spectral analysis of a thulium doped ZBLAN fiber pumped with 645nm and 687nm

The spectral analysis of a Tm: ZBLAN fiber laser cavity was performed when it was pumped by two wavelengths (645nm and 687nm). We excited the 3F3 and 1D2 levels of the thulium bands to obtain (laser) emission in the blue and ultraviolet regions at wavelengths of 450nm and 365nm by up-conversion (if possible to obtain 475nm by the excitation of the 1G4 band). Different fiber lengths (30 and 60 cm) were studied all with a concentration of 4500 ppm / wt. We also tried different cavity configurations by changing the output coupler (i.e., reflectivity at the output). It is observed that for shorter fiber lengths the emission of the spontaneous amplified emission (ASE) of the band at 450 nm is sharper than for longer fiber lengths,

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in addition the 365 nm band is also affected by the variation of the fiber length. The pumping powers were constant in all configurations.”

P29 • Alba María Jumbo Nogales • Escuela Politécnica Nacional

Synthesis and optical characterization of CdS and CdSe nanoparticles

Nanoparticles are structures with dimensions less than 100 nm. Semiconductor NPs are very important for applications in energy, environmental studies, as biosensors, etc. The NPs size is a fundamental characteristic that determines its physical properties. CdS semiconductor nanoparticles were made in Water-heptane reverse micelles and characterized by UV-Vis-NIR absorbance and fluorescence. The effect of the molar-water fraction in the micelle on NP size has been investigated. AOT are molecules made of two organic chains attached to a polar group a used for NP stabilization in the micelles. The size of the NPs synthesized inside of reverse micelles is controlled by varying the amount of water present in the system. The molar ratio water:AOT correlates with the final size of micelle. The absorption and fluorescence spectra of the particles in suspension were measured and related to their diameter. The size of CdSe nanoparticles was modified by the variation of the quantity of thioacetamide added during the chemical synthesis process. We aimed to study the interaction of the NPs in the aqueous phase of the micelle, with organic pigments by observation of their absorption and fluorescence spectra. Putative physical and chemical interactions between the pigment molecules and the NPs should be evident in this way. In this work we also explore the extraction of the (NPs) from the micelles to further determine their stability.”

P30 • Javier Jurado • University of São Paulo

Application of the Zero-Order Phase Contrast Technique in Optical Trapping

We evaluate the application of the zero-order phase contrast technique for the generation of multi-beam traps in an optical trapping system. This technique uses an aperture in the Fourier plane of a 4f optical correlator to reconstruct intensity distributions from phase distributions coded onto a diffractive optical element.

P31 • Mosima Kgomo • CSIR-National Laser Centre

Fusion Splicing of Double-Clad Large Mode Area Fibres for Fabrication of High Power Fibre Laser

Fibre based lasers have become a dominant laser architecture due to high output powers and efficiencies, compact form factors, and excellent beam quality. Double-clad large mode area fibres are required to achieve high output power (up to kW level). The performance and integrity of an all-fibre laser is critically dependent on the quality of splices between different components constituting a fibre laser. Fusion splicing is the technique used to interconnect fibres and fibre components. Power loss at the splice joints (splice loss) has a deleterious effect on the performance and long-term reliability of high power fibre lasers. Splice losses, caused by poor fusion splices, lead to a decrease in the optical-to-optical efficiency as well as degradation in the beam quality of fibre lasers. Obtaining low loss fusion splices remains a challenge in the development of fibre lasers. To address this problem, splice loss experiments were conducted to find the best parameters that can be used to produce low splice losses. Due to the large number of splice parameters, the experimental methodology made use of fractional factorial design which enables the reduction of the required number of experiments by performing them at a certain specific combination of parameters. A system was setup to conduct splice loss measurements. The splice loss results were analysed by using a statistical tool called analysis of variance (ANOVA) will be presented.

Student Poster Competition Abstracts

P32 • Nicholas Kochan • University of Rochester

Raman Spectroscopy for Measurement of Gradient Index Optics

Raman spectroscopy serves as a promising tool for nondestructive measurement of material composition along the surface of a polymer gradient index of refraction (GRIN) lens. The distribution of the material correlates with the index of refraction profile through the optic. The Raman method is validated against Pulfrich refractometry and nuclear magnetic resonance spectroscopy as measurement standards. This project shows the flexibility and effectiveness of using Raman spectroscopy to identify the registration of the GRIN surface profile with respect to the mechanical optical axis of the lens element. The expected GRIN lens surface profile is accurately observed using scanning confocal Raman microscopy.

P33 • Charlotte Kyeremah • University of Cape Coast

Transformation of Orbital Angular Momentum (OAM) using a Mode Sorter

A study has been made on the generation and measurement of orbital angular momentum (OAM) state of light from a simple Gaussian mode using computer-generated hologram (CGH) and a refractive optical element (mode sorter) to efficiently sort OAM states of light. A Laguerre-Gaussian (LG) mode of laser light was used as the beam carrying OAM. These modes, each characterized by an integral index l , carries an OAM due to their helical phase front. The optical element performs a Cartesian to log-polar coordinate transformation, transforming the helically phased light beam corresponding to OAM states into a beam with a transverse phase gradient. A Fourier transforming lens then focuses each input OAM state to a different lateral position. Multiple (Superposition) beams were also sent through the system using the same approach. This concept was demonstrated experimentally to test the performance of the communication system, applying it to the separation of forty-one OAM modes.

P34 • Simon Lehnkov Lange • Technical University of Denmark

Demonstration of a peak electric field sensitive terahertz camera

We demonstrate a novel terahertz (THz) camera which maps the cross-sectional intensity distribution of THz field transients and is sensitive to the peak electric polarity and field strength. The camera effectively up-converts THz frequencies through field ionization of noble gasses with a glow discharge in the UV-vis regime. The camera is based on ultrafast electron field emission from metal antennas due to strong THz pulse irradiation. As the emission is strongly nonlinear with the electric field strength, we demonstrate how to maximize the total emission using periodically structured Au coupled split ring resonator antennas on a Si/SiO₂ hetero-substrate. The antennas enhance the peak electric field in a large, few μ m-sized gap designed to avoid metal damage due to electron bombardment as well as nonlinear effects in the substrate. The electron field emission subsequently excites surrounding argon molecules that undergo radiative relaxation in the CCD-sensitive UV-vis regime. The latter is recorded with a standard commercial camera. Hence, the setup constitutes a novel THz camera that outperforms both pyrocams and microbolometers in terms of reduced size, price and frequency tunability.

Student Poster Competition Abstracts

P35 • Jiaming Li • Huazhong University of Science & Technology

Laser-Induced Breakdown Spectroscopy assisted with Laser-Induced Fluorescence

Laser-induced breakdown spectroscopy (LIBS) is a laser-ablation-based spectrometry with advantages of fast response, remote sensing, real-time monitoring, no sample preparation, etc. However, LIBS still suffers from weak emission, poor sensitivity, spectral interference, and self-absorption effect. Here, we introduce LIBS assisted with laser-induced fluorescence (LIBS-LIF). The target atoms in plasmas are resonantly excited by a wavelength-tunable laser and emit fluorescence. The optical emission of target atoms is selective enhanced. The sensitivity was improved, and the spectral interference was eliminated. Moreover, the cold atoms in plasmas causing self-absorption effect are stimulated and transitioned up to high levels. The optical emission is much less re-absorbed by these cold atoms. Therefore, the self-absorption effect is effectively reduced. In summary, LIBS-LIF is capable to improve improving spectral intensity, detective sensitivity, analytical linearity and accuracy in LIBS.

P36 • Keigo Masuda • Chiba Univ

Light induced chiral surface relief

Helical lights, e.g. optical vortex and circularly polarized lights, carry optical angular momenta such as orbital angular momentum (OAM), spin angular momentum (SAM), and total angular momentum defined as the sum of SAM and OAM. They have been studied in many research fields, such as optical manipulations, quantum optics, and optical communications. In recent years, optical vortex material processing, in which OAM of optical vortex is transferred to a target material so as to fabricate a chiral structure on a sub-micron scale, has been proposed, however, its mechanism, e.g. how does optical angular momentum contribute to the chiral structure fabrication? has not been fully understood yet. We are currently working on the chiral surface relief formation in an organic azo-polymer film by illumination of continuous-wave optical vortex beam possessing OAM, and a circularly polarized Gaussian beam only with SAM without any OAM. We discovered that the chiral surface relief is formed by spin-orbital coupling effects in the azo-polymer thin film.

P37 • Sadhu Moka • University of South Florida

Multi-frequency Frequency Domain Diffuse Optical Spectroscopy with digital demodulation

We present a novel Frequency Domain Diffuse Optical Spectroscopy (FD-DOS) method for the measurement of baseline tissue optical properties at a single source-to-detector (s-d) separation. Conventional FD-DOS systems illuminate tissue with intensity modulated light, & estimate tissue absorption/scattering from the amplitude/phase changes of light detected signal at many s-d separations. Instead, we use digital synthesis to vary the modulation frequency of illumination, and measure frequency dependent amplitude and phase at a single s-d separation (per Torjesen et al.); tissue absorption/scattering is estimated by fitting the measured data to a semi-infinite solution of the photon diffusion equation. Importantly, our approach employs user-friendly off-the-shelf USB data acquisition and LabVIEW integration, for signal synthesis/demodulation thereby reducing complexity/overhead & improving flexibility. We also characterize the technique & identify optimum operating parameters for accurate estimation of optical properties.

Student Poster Competition Abstracts

P38 • Prince Mredlana • CSIR

The Wigner distribution function in characterising general optical fields of varying coherence

The coherence of optical fields is a defining factor in how they are represented and characterized, in this work we employ the Wigner Distribution Function (WDF) for a generalized optical field characterization method. We characterize a Gaussian-Schell model partially coherent beam by determining the beam width, divergence, curvature and beam quality factor of the pure field from the mutual correlation function and its corresponding WDF. The beam is digitally encoded using an SLM. The WDF is a space-frequency representation and in the spatial domain, we find comparable accuracy between the parameters obtained using the pure optical field and the WDF.

P39 • Nagarajan Nallusamy • Sastra University, India

Highly sensitive nonlinear temperature sensor based on modulational instability technique in liquid infiltrated photonic crystal fiber

A highly sensitive nonlinear temperature sensor is theoretically proposed using the modulational instability (MI) process with the temperature dependent wavelength shift of generated Stokes and anti-Stokes sidebands. Based on the pumping regime the sensor is studied in both anomalous and normal dispersion regime in the Cs₂ filled photonic crystal fiber (CSPCF). A sensitivity of -0.4003nm/oC is achieved by the shifting of Stoke sideband shift of anomalous dispersion regime. The sensitivity is increased by 66 times than that of anomalous dispersion regime which pulsed is launched in to the normal dispersion regime. In order to get a good stable temperature sensor the proposed CSPCF sensor could be optimized by tuning the structural parameters like air hole size and diameter of the air hole and pulse propagation parameters are tuned by changing the pumping wavelength and pump power. This proposed nonlinear temperature sensor which is made up of an appropriate structure of CSPCF having a length of 13 cm exhibits a sensitivity of -82 nm/OC using Stokes line and 435 nm/OC using anti-Stokes line while pumped with a power of 100 W in the normal dispersive region.

P40 • Rajveer Nehra • University of Virginia, Charlottesville

Heisenberg-limited quantum interferometry with photon-subtracted twin beams

In a classical interferometer, the vacuum fluctuations at the idle input port limit the phase difference sensitivity between the two interferometer arms to the shot-noise limit of the input beamsplitter [1]. When both input modes of the interferometer are properly quantum engineered, one can, in principle, reach the ultimate limit, called the Heisenberg limit [2]. We study a new type of quantum interferometer, based on an indistinguishably photon-subtracted twin-beam input. Such an interferometer can yield Heisenberg-limited performance while at the same time giving a direct fringe reading unlike the simple twin-beam input [3]. We propose a feasible experimental realization employing an optical parametric oscillator below threshold.

P41 • Carlos Ochoa • CICESE

Characterization of a Single-Frequency Diode Laser

We study the performance of a laser diode of wavelength 825 nm and power 200 mW which is frequency-locked using grating feedback. We present measurements of the output laser power as a function of diode current for several temperatures. We also investigate the spatial beam structure and determine its ellipticity. We present evidence for mode hopping under various conditions, and draw conclusions as to how to achieve laser stability.

Student Poster Competition Abstracts

P42 • Ogaga Odele • Purdue University

Two-photon interference with quantum frequency combs

We present a novel approach for examining phase coherence across a quantum frequency comb. Our scheme relies on electro-optic phase modulation in conjunction with spectral phase shaping. First, we show a proof-of-concept experiment using frequency-bin entangled photons created via spectral amplitude shaping of broadband biphotons. Subsequently, we apply this technique to verify phase-coherence of an on-chip optical microresonator quantum frequency comb for the first time. Our work has the potential to contribute towards scalable high-dimensional quantum information processing.

P43 • Yusuf Panbiharwala • Indian Institute of Technology Madras

Investigation of power scaling issues in Yb-doped high power fiber lasers

Our work focuses on investigation of power scaling issues in Yb-doped high power fiber lasers. We develop a multi-stage master oscillator power amplifier (MOPA) setup where output from a relative low power stable laser source is amplified using multiple amplifier stages to about 500W. Usually nonlinear effects such as stimulated Brillouin scattering (SBS) limits the power in such fiber amplifiers with narrow linewidth laser source. We observed the occurrence of pulses also known as modulation instability initiated due to SBS in backward direction of an amplifier which limits its output power. We study the threshold for such pulse occurrence for various source linewidth. Usually the nonlinear threshold like SBS is scaled in fiber amplifiers by increasing the core diameter i.e. making the fiber multi-moded. In such fibers at higher power levels due to formation of thermal grating in fiber core, power tend to transfer rapidly between modes of the fiber (known as thermal mode instability, TMI) which limits the output power. We also plan to study the dependence of source laser linewidth on TMI threshold.

P44 • Akhilesh Kumar Pathak • IIT(ISM),Dhanbad

Tripple point tapered PCF based refractive index sensor

In this paper we fabricate and demonstrate a tapered PCF based refractive index(RI) sensor. Tapered probe was fabricated by using chemical method which was later then splice with SMF from both end. From the obtained result it was observed that tapering causes the enhancement in the sensitivity. Highest obtained sensitivity was 28.67 dBm/RIU at 1550 nm by linear fitting of the graph in origin. Highest sensitivity in comparison to conventional fiber make it useful in various field of chemical sensing.

P45 • Maria Pawliszewska • Wroclaw University of Science and Technology

Nanomaterial-based saturable absorbers for ultrafast holmium-doped fiber lasers

Numerous applications of lasers emitting ultrashort optical pulses beyond 2 μ m include surgeries, spectroscopy, micromachining, and telecommunications. This motivates the photonic community to continue the research on pulsed laser sources based on holmium-doped crystals and fibers, which are capable of reaching wavelengths up to 2.2 μ m. This work presents successful usage of novel two-dimensional materials: black phosphorus and graphene for mode-locking all-fiber lasers utilizing holmium-doped active fibers as a gain medium. Methods of manufacturing fully fiberized saturable absorbers based on graphene/PMMA composite and solution of black phosphorus will be shown. Two laser setups will be presented along with comparison of their performance. The generated optical solitons centered at 2070 \pm 2090 nm reach pulse duration of \sim 800 fs, and pulse energy of 2.2 nJ.

Student Poster Competition Abstracts

P46 • Emily Pendleton • University of Georgia

Characterization of Collagen Fibers using Polarization-Resolved Second Harmonic Generation

We present the use of polarization-resolved second harmonic generation (SHG) imaging to characterize collagen fiber orientation and organization in whole bone tissue in a murine Hypophosphatasia (HPP) model. HPP is a devastating genetic disease caused by limited bone mineralization due to impaired alkaline phosphatase (ALP) function. Since HPP has such a profound impact on bone growth and strength, we hypothesize that HPP has a significant impact on collagen organization and formation in the bone as well. Here, our work seeks to describe the collagen organization in the HPP murine model. We use a home-built 2-photon microscope with a 775nm femtosecond pulsed laser for SHG in whole bone samples. To evaluate the organization of collagen fiber bundles in the bone, we perform polarimetric analysis of collagen fiber signal with polarized femtosecond pulsed laser excitation. With our two-photon microscope, the growth of the collagen matrix can be tracked and quantified. We measure the effect of disease on light propagation and detected SHG in the tissue. In addition, we use an analytic approach to model the Zernicke modes of aberrations generated by healthy and disease bone. Deficiencies in the collagen matrix such as pores and collagen alignment are also measured. The results of our studies could describe improvement of collagen organization in response to therapy and may improve prognosis in HPP patients.

P47 • Wu Peng • University of Chinese Academy of Sciences

Studies on Yb-doped superfluorescent fiber source

We modeled the spectra evolution in superfluorescent fiber source, based on steady-state equations, to study the dependence of output characteristics on the length of gain fiber and pump power. The configuration adopted by our model included seed source and amplifier stage. For the seed, with the increase in fiber length, red-shift of central wavelength appeared. When pump power raised in a certain range, blue-shift of central wavelength and spectrum narrowing emerged. The evolution in amplifier stage showed some familiar characteristics, but we found when the pump power was high, the influence of temperature on output spectrum can't be neglected and it will display some opposite phenomenon. The above study of spectra evolution will provide a useful guidance for the design of superfluorescent fiber source. Besides, it will also benefit some applications which are sensitive to wavelength, such as beam combining.

P48 • Benjamin Perez-Garcia • Tecnologico de Monterrey

Controlled generation of non-homogeneous polarized beams

We present an optical system to generate optical vector beams. Our scheme provides control over the polarization state across the transverse plane, which can be custom defined and dynamically changed. We generate several instances of vector beams using our apparatus, showing good agreement with the desired polarization distribution.

Student Poster Competition Abstracts

P49 • Julio Cesar Quiceno • Universidad del Valle

Diffraction of optical vortex by annular aperture

We analyze the far-field diffraction intensity pattern of an optical vortex after passing through an annular aperture. Using the transmittance function of a circle and the Babinet Principle is possible calculate the complex amplitude of the transmitted wave in which the azimuthal phase factor survives. To evidence of the conservation the topological charge of transmitted beam we show the great definition achieved in the interference pattern in the assembling Mach-Zehnder type setup, between the optical vortices filtered by annular aperture and spherical wave of reference. The interferograms were recorded for different topological charges. Experimentally we recover a technique of chemical photography to build diffractive optical elements with micrometer resolution, essentially for making fork-shaped holograms and circular annular aperture. In both cases the images were simulated in high resolution with the Matlab program (The MathWorks, Inc) and printed on paper, and then will be transferred onto a film of acetate Kodak by analog photography. The negative film was developed according to manufacturer's instructions for black and white film increasing the contrast.

P50 • William Serrano García • University of South Florida

Electrospinning Technique for Fabrication of Flexible Electronic Devices

The electrospinning technique is a low cost and reliable method that has been broadly used in the fabrication of nanofibers for intelligent textiles, filters and bone scaffolds to mention some of its applications. This work is intended to use organic semiconductor polymers for electronic device fabrication leading in nanodisks that are expected to work as diodes and sensors. These organic polymers have been noted to have excellent thermal stability, electrical conductivity, mechanical flexibility and chemical/biological functionality. The p-type Poly(3-hexylthiophene-2,5-diyl) (P3HT) regioregular and the n-type Poly(benzimidazobenzophenanthroline) (BBL) are used in this work. Under a coaxial structure, P3HT as the core and BBL as the sheath of the nanofibers, a cylindrical p-n junction is formed. This research looks forward to expand the knowledge in organic polymeric semiconductors for efficient flexible arrays with better performance and lower power requirements as well as advancing the electrospinning technique as well as the usage of optical tweezers to manipulate the nanodisks for specific applications. This process will help establish a reliable procedure for a predictable formation of the coaxial electrospinning set up for organic semiconductors.

Student Poster Competition Abstracts

P51 • Vishal Sharma • IIT Jodhpur, Rajasthan, India

Analysis of Quantum Satellite Communication Under Atmospheric Effects

Quantum key distribution is an effective encryption technique which can be used to perform secure quantum communication between satellite and ground stations. To achieve this task effectively, satellites are deployed to distribute single photons and entangled photons that provide unique solution for long-distance quantum communication networks. This solves the principle limitations of Earth-bound technology afforded by both optical fiber and terrestrial free-space links. In real field applications, there are major challenges such as sensitivity to the environment and high attenuation. For improving the quality of service of satellite quantum communication, we need to consider the security and quantum throughput efficiency by correcting the errors introduced due to eavesdropping and noise. To eliminate these problems, the noisy quantum channel is modelled and implemented with an effective quantum error correction method to get perfect security and to improve the efficiency of the satellite-ground communication. The simulation results obtained by the redundancy-free quantum error correction scheme gives better security and throughput efficiency. We have developed a thorough numerical simulation using realistic simulated orbits and incorporating the effects of atmosphere and telescope design, to obtain estimates of the loss and background noise which a satellite-based system would experience. We calculate the length of secure key for QKD, as well as entanglement visibility and achievable distances. We analyze the performance of a low Earth orbit (LEO) satellite for downlink and uplink scenarios of the quantum optical signals. We argue that the advantages of locating the quantum source on the ground justify a greater scientific interest in an uplink as compared to a downlink. An uplink with a ground transmitter of at least 25 cm diameter and a 30 cm receiver telescope on the satellite could be used to successfully perform QKD with either an entangled photon source or with a weak coherent pulse source. Our analysis help to resolve important design considerations such as operating wavelength, type and specifications of sources and detectors, telescope designs, specific orbits and ground station locations, in view of anticipated overall system performance.

P52 • Sanyogita Singh • Indian Institute of Technology Kanpur

Design, study and characterization of optically tunable micro dye laser system

Integration of MEMS technology with Fluidics and Optics known as Opto-fluidics offers many advantages in various applications from cost and performance point of view. The present research aims at development of dye lasers in a microfluidics platform and subsequent integration with complete lab-on-a-chip systems for biomedical application. The fabrication will be primarily carried out using femtosecond laser micro machining technology in glass/PDMS . The tuning will be carried out using magneto-fluidics principle. Preliminary design studies are reported using optical simulations. Sample fabrication using femtosecond laser micromachining is demonstrated.

P53 • Adelcio Souza • University of Sao Paulo

Double Cavity Self-Seeding WDM-RoF link for Fronthaul Applications

We propose a double cavity self-seeding technique in Wavelength-Division Multiplexing Radio-over-Fiber (WDM-RoF) link for mobile networks fronthaul applications. Future mobile networks are expected to have a large number of small cells for seamless coverage, which increases the number of required radio units. One promising solution is a Centralized-Radio Access Network (C-RANs) that uses RoF technique to connect various radio units to a single central office. This can be done through a WDM passive optical network (PON), but a unique wavelength transmitter must be assigned for each optical network unit (ONU),

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which increases operation and management complexity. To address this issue, self-seeding schemes have been proposed to provide colorless transmitters. This technique consists of using an array waveguide (AWG) to slice the amplified spontaneous emission (ASE) of a reflective semiconductor optical amplifier (RSOA) and reuse the output to self-seed the transmitter. In our topology, we use two RSOAs in different states of polarization to allow double optical carrier suppression and provide a systematic gain over other regular topologies, providing a lower cost alternative for solving the inventory management problem for wavelength assignment in WDM-RoF links.

P54 • Ramon Springer • University of Erlangen-Nürnberg

Temporal Pulse Shape Modulation in Single-Pass Solid State Amplifier

This poster demonstrates a one dimensional numerical model for single-pass solid state laser amplifiers. It is shown that after amplification the temporal shape of individual pulses within a pulse train can significantly vary, which results in an unstable interpulse spacing and a non reliable temporal pulse stability. Moreover possible adjustments of the pump pulse duration are pointed out in order to secure a stable temporal intensity output of the seed pulse train. In detail, the model is based on a non-linear time-dependent photon transport equations combined with a four level rate equations system and a pulsed end-pumping configuration.

P55 • Hend Sroor • University of The Witwatersrand

The Fractal Laser

Self-similar fractals are mathematical series that manifest identical replicated patterns at every scale. They are described by a mathematical equation that is nowhere differentiable. Recently, fractals have found their way into a myriad of applications such as fractal antennas, transistors, digital imaging and fractal cosmology science. Theoretical simulations show that unstable optical laser resonators contain a special, self-conjugate plane, in which the eigenmodes not only have the same pattern but are also magnified copies of themselves. Here, we show a novel optical resonator that is capable of generating eigenmodes with these self-similar fractal features. Depending on the beam path inside the resonator, our novel resonator is considered an analogue to both the monitor inside monitor effect and monitor outside monitor effect. The fractal feature is proved by finding a typical image of the eigenstate at different scales as well as by measuring the fractal dimensions of the eigenstates.

P56 • Nyasha Suliali • National University of Science and Technology

Micron-scale surface cross-section profilometry of step-function-surfaced optical elements using spectral-domain optical coherence tomography

Micron-scale surface cross-sectional imaging was demonstrated on an optical element using a prototype spectral-domain optical coherence tomography imaging system. The sample was constructed by pasting a microscope slide cover-slip onto a plane mirror. Resolution of the system was highest at 12 μm when the spectral interferometer was illuminated by a 635 nm LED. Data acquisition was implemented by means of a 2048-pixel Czerny Turner mount monochromator which detected interferometer spectra. A First Reflection Surface Profilometry algorithm is described from formulation to implementation in MATLAB[®]. Surface shape and inclination relative to the incident sample arm beam was performed with a standard deviation of 1 μm . A description of software implemented to optimise operation of this prototype is given.

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P57 • Nathália Tomazio • University of Sao Paulo/Sao Carlos Institute of Physics
Low threshold Rhodamine doped microlasers fabricated by direct laser writing

Whispering gallery mode polymeric microcavities benefit from the combination of the strong light confinement of whispering gallery modes with the flexibility and ease of processing/shaping of polymers. Nevertheless, the fabrication of polymeric nano/microdevices with high performance remains challenging. In this work, we report laser action in Rhodamine B doped whispering gallery mode microcavities fabricated by femtosecond laser induced two-photon polymerization. The cavities are on-chip integrable microcylinders, which exhibit good structural quality, low-shrinkage and smooth sidewalls. Unlike most methods used to produce microlasers, Rhodamine B is directly incorporated into the polymeric host matrix, which does not affect significantly the optical properties of the dye. The lowest laser threshold was measured at 12 nJ of pump energy for free-space pulsed excitation at 532 nm. Such performance was achieved for microcavities fabricated in a single step of direct laser writing, which, as far as we know, had not been demonstrated previously. This work therefore represents a step forward in the field of soft photonics and demonstrates the potentiality of two photon polymerization in fabricating high performance optical microdevices.

P58 • Roman Torres Romero • BenemÉrita Universidad AutÓnoma de Puebla

Numerical model to describe z-scan curves in thick nonlinear media considering linear absorption

This work is based on the development of a numerical model which describe z-scan curves considering that the length material is much greater than z_0 (Rayleigh distance). This material is studied as a set of photo-induced lens with variable focal length F . This model describes z-scan curves of numerical way with different lineal absorption coefficients and different sample lengths. The numerical results they were compared to experimental results getting a better approximation, these ones were made with isopropyl alcohol and organic dye; of results it was observed that transmittance peak increases as a function of sample length. However for some value of the lineal absorption coefficient and the medium thickness, the maximum transmittance decreases, is observed also that the sample position is shifted to the left while the valleys remain almost in the same position. In conclusion, with the z-scan curves we can determine the sign, the magnitude of the refractive index, and the nonlinearity of the material.

P59 • Sultan Abdul Wadood • Institute of Optics, University of Rochester

Laser noise as a function of beam splitter transmissivity

Beam splitters are important linear optical elements. In a quantum mechanical treatment, vacuum fields at the empty port of a beam splitter are required to maintain the commutation relations. This implies that a laser maintains its Poisson nature after the beam splitter. The beam splitter äaddsí enough noise to keep the laser shot noise limited. We experimentally verify the expected shot noise behavior as a function of the beam splitter transmissivity. The model predicts that modifying the vacuum port properties can lead to a change in the observed noise. A possible application of squeezing is discussed.

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P60 • Banafshe Zakeri • Duisburg-Essen University

Label-Free and Site-Specific Probing of Molecular Recognition by Ultraviolet Resonance Raman Spectroscopy (UVR)

Vibrational Spectroscopy is a suitable method for monitoring of molecular recognition processes due to the high sensitivity to small changes in length and strength of the binding. In particular, in the case of artificial peptide ligands, this method can help to investigate a better understanding of the interplay of different interactions. However, so far surprisingly few application examples are available for molecular recognition specially in the field of Supramolecular chemistry. One reason is that interpretation of the spectral change in the vibration spectra, mostly by band assignment, can be very complex for large molecules. One way of simplifying the vibration spectra is to use the selective vibration spectroscopy, e.g. the Resonance Raman Spectroscopy. Here, we report on the first application of Ultraviolet Resonance Raman Spectroscopy (UVR) for site-specific and label-free monitoring of a protein by supramolecular ligand. Supramolecular ligands for peptide recognition are powerful tools for investigating the principles of protein-protein interactions. Schmuck and co-workers have developed synthetic ligands comprising a guanidiniocarbonyl pyrrole (GCP) moiety as an efficient binding site for carboxylate side chains of peptide and proteins, even in polar solvents such as water. In this work, we use the site-specificity of UVR for probing a molecular recognition between a multi-armed GCP ligand and an alpha-helical protein named Leucine Zipper. A 90° scattering geometry with a rotating cell in combination with 266 nm excitation wavelength from a cw solid-state laser was employed to selectively enhance the vibrational Raman bands of the GCP subunit in the free and complexed form upon addition of Leucine Zipper.

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About



In keeping with its mission to promote the generation, application, archiving and worldwide dissemination of knowledge in optics and photonics, The Optical Society (OSA) established the OSA Foundation in 2002 to carry out a wide range of charitable activities.

The OSA Foundation is a non-profit organization that relies on the generous financial support of donors to help graduate students and early career professionals as they become active members of research, engineering and corporate communities around the globe. Foundation-sponsored travel grants, prizes, scholarships, fellowships and programs are just some of the ways donor contributions directly benefit these innovators and leaders of tomorrow. Enabled by engaged contributors like you, the Foundation also works to secure OSA Awards and Honors Program endowments.

As has been the case since the OSA Foundation's earliest days, every donation is matched 100% by The Optical Society's contributions to the OSA Foundation's General Fund. OSA's commitment to the Foundation and its matching program allows every gift to make twice the impact!



The Centro de Investigaciones en Óptica - CIO - is a public research center aimed to develop basic and applied research in the field of optics and photonics, thus contributing to the scientific community efforts in order to advance the frontiers of knowledge as well as to foster its applications in the productive and social sectors in Mexico; in addition to the education of highly qualified talent, the technology development and transfer, and the formation of a scientific and technological culture for the Mexican people.

CIO contributes the scientific knowledge by carrying theoretical and experimental research in optics and related disciplines; strengthens the scientific and technological capacities of Mexico by educating internationally-standard talent; contributes the technological growth of Mexico by means of the technology development and transfer; and helps developing a scientific and technological culture for the Mexican people by spreading and diffusing the scientific knowledge.

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About



The Optical Society's (OSA) mission is to promote the generation, application and archiving of knowledge in optics and photonics and to disseminate this knowledge worldwide. The purposes of the Society are scientific, technical and educational. OSA's commitment to excellence and long-term learning is the driving force behind all its initiatives.

Since 1916, OSA has been the world's leading champion for optics and photonics, uniting and educating scientists, engineers, educators, technicians and business leaders worldwide to foster and promote technical and professional development. Through publications, events and services, Optical Society is helping to advance the science of light by addressing the ongoing need for shared knowledge and innovation.

OSA was founded exactly 101 years ago as The Optical Society of America and has evolved into a global enterprise serving a worldwide constituency. In recognition of its global reach and focus, since 2008 the Society has been known as OSA—The Optical Society.

NOTES



Applications for the 2018 School will be accepted starting in late fall.



The Siegman International School on Lasers

Education. Interactions. Experience.

Each summer, The Siegman International School on Lasers invites up to 100 graduate students for a week-long program to learn from pioneering laser researchers and experts from leading laser companies, highly-regarded professors and fellow students. In addition, attendees present their own research and gain invaluable experience in building exposure for their work.

osa.org/siegmanschool

Previous Locations:

2017: Centro de Investigaciones en Óptica, Leon, Mexico

2016: The Institute of Photonic Sciences, Barcelona, Spain

2015: Max Planck Institute, Amberg, Germany

2014: Stanford University, Palo Alto, California, USA

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