QUEST 2023

International Conference on

Quantum Engineered Sensing and Information Technology

June 27-30, 2023
Hotel Mercure Paris 19 Philharmonie-La Villette,
216 Av. Jean Jaures, 75019 Paris, France

CONFERENCE CHAIR
Prof. Manijeh Razeghi
Benjamin Franklin Award
(2018)

HONORARY CO-CHAIR
Prof. Leo Esaki
Nobel Prize in Physics
(1973)

HONORARY CO-CHAIR
Prof. Klaus Von Klitzing
Nobel Prize in Physics
(1985)

Prof. Gerard Mourou
Nobel Prize in Physics
(2018)

Prof. Alain Aspect
Nobel Prize in Physics
(2022)

Prof. Albert Fert
Nobel Prize in Physics
(2007)

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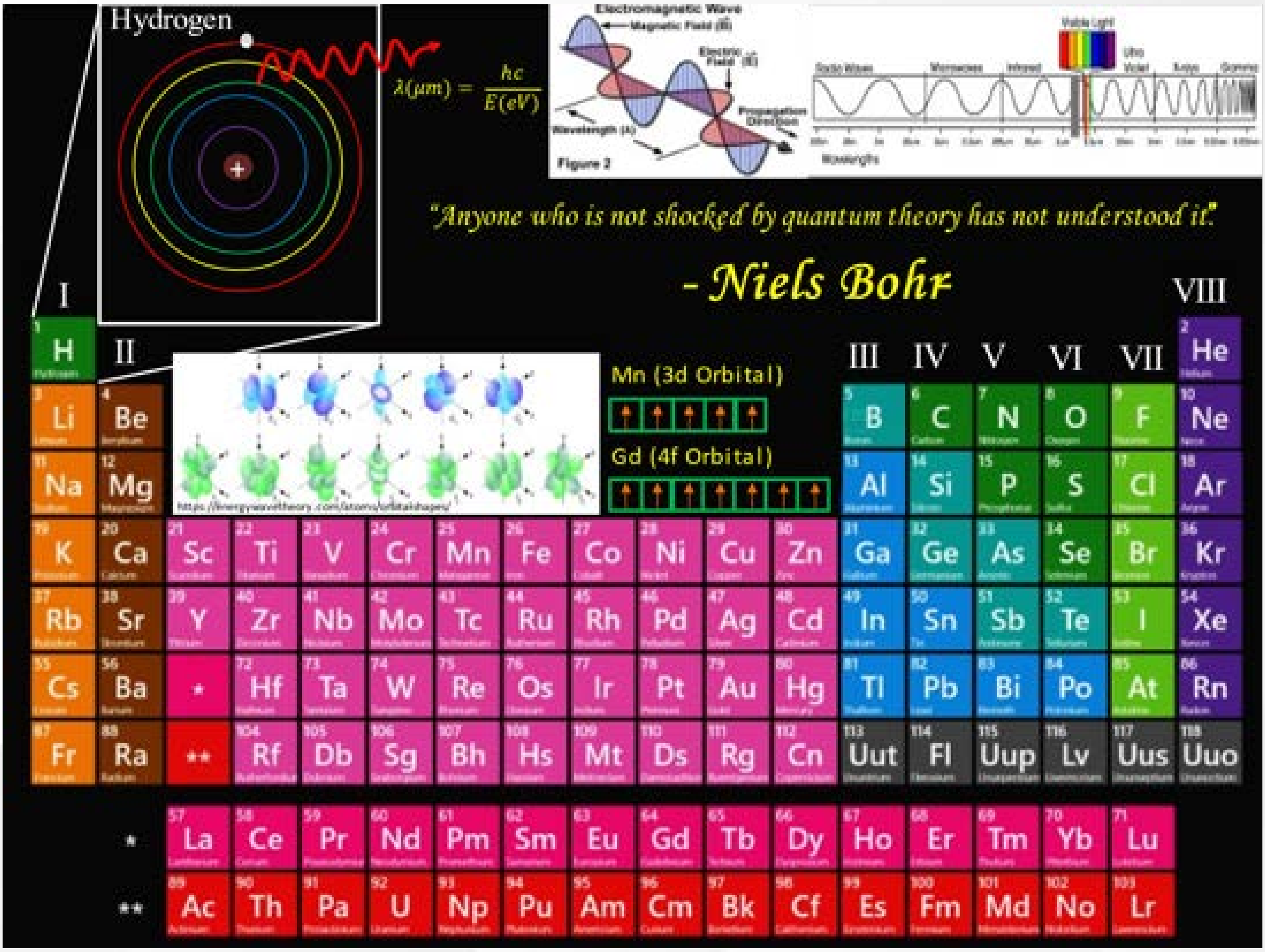
(1985)

Recent understanding of Quantum Science and Technology has exceeded our expectations for meeting the requirements of human society for different applications, such as telemedicine, in the 21^{st} century. Free-space optical (FSO) communication is one of the key technologies for realizing ultra-high-speed multi-gigabit-per-second (multi-Gb/s) large-capacity communications. Using lasers as signal carriers, FSO laser communications (Laser-Com) can provide a line-of-sight, wireless, high-bandwidth, communication link between remote sites. Rapidly growing use of the internet and multimedia services has created congestion in the telecommunications networks and placed many new requirements on carriers. IR Laser transmitters offer an intermediate low risk means to introduce desired network functionalities with extremely high bandwidth, over conventional RF wireless communications technology, including higher data rates, low probability of intercept, low power requirements, and much smaller packaging. Spintronics as another emerging field for the next-generation quantum devices using the Spin degree of freedom of Electrons / Holes, Neuromorphic engineering, etc.

Nature offers us a full assortment of atoms, but Quantum engineering is required to put them together in A Smart an elegant way to realize functional structures not found in nature on our planet earth.

A particular rich playground for Quantum era, is the so-called semiconductors, made of different atoms from the periodic table, and constituting compounds with many useful optical and electronic properties. Guided by highly accurate simulations of the electronic structure, modern semiconductor quantum devices are literally made atom by atom using advanced growth technology to combine these Atoms Into materials in Such ways to give them new proprieties that neither material has on its own. Modern mastery of atomic engineering allows high-power and highly efficient functional Quantum devices to be made, such as those that convert electrical energy into coherent light or detect light of any wavelength and convert it into an electrical signal.

This historical conference will present the future trends and latest world-class research breakthroughs that have brought quantum Science and Technology to an unprecedented level, creating light detectors and emitters over an extremely wide spectral range from deep Uv to Thz (0.2 to 300 microns), as well as their integration with Si photonics. Inspiring by Nature, to find solution to fight with power of nature against human life!



Hydrogen
$\lambda(\mu m) = \frac{hc}{E(eV)}$
Electromagnetic Wave
Figure 2
"Anyone who is not shocked by quantum theory has not understood it."
- Niels Bohr
I
II
III IV V VI VII
VIII
Mn (3d Orbital)
Gd (4f Orbital)
H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba * Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra ** Rf Db Sg Bh Hs Mt Ds Rg Cn Uut Fl Uup Lv Uus Uuo
* La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
** Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

QUEST 2023

International Conference On
Quantum Engineered Sensing And Information Technology

DAY 01
TUESDAY, JUNE 27

Hall Name: ETOILE LOUVRE

08:00-08:30	**Onsite Registrations**
08:30-09:00	**Opening Remarks**

Session - 1

Conference Chairs: **Prof. Manijeh Razeghi, Prof. Leo Esaki, Prof. Klaus Von Klitzing**

Plenary Talk

09:00-09:30	**Prof. Albert Fert, UMR CNRS-THALES, Université Paris-Saclay** Title: Spintronics: Turning greener the digital technologies and far beyond with skyrmionics, neuromorphic nanochips or orbitronics
09:30-10:00	**Prof. Gerard Mourou, École polytechnique Palaiseau, France** Title: Searching for Extreme Light
10:00-10:30	**Coffee Break@ TROCADERO**

Session - 2

Session Chairs: **Dr. Martin Defour, Dr. Ferechteh Hosseini Teherani**

Plenary Talk

10:30-11:00	**Dr. Jean-Pierre Huignard, Prof. Paul-Louis Meunier and Prof. Manijeh Razeghi** Title: Historical information about, Thomson CSF, Thales, and QUEST conference
11:00-11:30	**Dr. Bernhard Quendt, Chief Technical Officer, Thales, France** Title: The second Quantum Revolution from an industrial Perspective
11:30-12:00	**Prof. Jerzy M. Langer, Warsaw Scientific Society, Poland** Title: European Innovation Council -A star in the making
12:00-13:00	**Group photo & Lunch @ PANORAMIC**

Session - 3

Session Chairs: **Prof. Dr. Wolfgang Elaesser, Prof. Yeshiahu Fainman**

Plenary Talk

13:30-14:00	**Prof. Christos Flytzanis, Ecole Normale Supérieure, France** Title: Fashioning and Pumping up the Sound. Photodriven Coherent THz Acoustic Phonon Amplification and Quantum Cascade Saser Operation in Semiconductor Superlattices
14:00-14:20	**Prof. Amr Helmy, University of Toronto, Canada** Title: Semiconductor Circuits for Quantum Enhanced LIDAR Systems
14:20-14:40	**Prof. Mehdi Alouini, Institut Foton, UNIVREN/CNRS, Rennes, France** Title: Ultra-narrow linewidth self-adaptive photonic oscillator: From principle to product

14:40-15:00	**Prof. Joseph Friedman, The University of Texas at Dallas, USA** Title: Spintronic Phenomena for Reversible, Neuromorphic, and Reservoir Computing
15:00-15:30	**Coffee Break@ TROCADERO**

Session - 4

Session Chairs: **Prof. Masud Mansuripur, Prof. Yossi Paltiel**

15:30-15:50	**Dr. Andrew Thain, Space Systems, AIRBUS, Toulouse, France** Title: Space based quantum communications at Airbus
15:50-16:10	**Dr. Henri Jaffres, Université Paris-Saclay, Palaiseau, France** Title: Ultrafast spin-charge conversion in topological insulators surface states probed by THz emission spectroscopy
16:10-16:30	**Dr. Tonouchi Masayoshi, Osaka University, Japan** Title: Terahertz Emission Spectroscopy and Imaging of Semiconductor Heterostructures and Quantum Wells
16:30-16:50	**Prof. Ali Adibi, Georgia Institute of Technology, USA** Title: Phase-change Materials for Reconfigurable Metaphotonics
16:50-17:10	**Prof. Mauro Pereira, Khalifa University of Science and Technology, UAE** Title: Giant Control of GHz-THz Nonlinearities in Semiconductor Superlattices
17:10-17:30	**Dr. Sébastien Tanzilli, CNRS, Université Côte d'Azur, Institut de Physique de Nice, France** Title: An operational, real-field, entanglement-based quantum key distribution network
17:30-17:50	**Dr. Mikhail Belkin, Technical University of Munich, Germany** Title: Polaritonic Nonlinear Metasurfaces for Flat Nonlinear Optics in Mid- and Far-Infrared

END OF DAY 01

Hall Name: ETOILE LOUVRE

Session - 5

Session Chairs: **Dr. Bernhard Quendt, Dr. Jean-Pierre Huignard**

08:40-09:00	**Dr. Dafine Ravelosona, Spin-Ion Technologies, France** Title: Enhancing the Performances of Spintronic Devices using Ion Irradiation
09:00-09:20	**Prof. Pedram Khalili, Northwestern University, USA** Title: Spin-orbit torque switching of metallic antiferromagnets and ferrimagnets
09:20- 09:40	**Prof. Wolfgang Elaesser, Technische Universitat Darmstadt, Germany** Title: Quantum Sensing with Photon Correlations of Classical Light: Ghost Imaging, Ghost Spectroscopy and Ghost Polarimetry
09:40-10:00	**Dr. Taichi Otsuji, Tohoku University, Japan** Title: Graphene-based 2D Heterostructures for Plasmonic Terahertz Laser Transistors and Detectors
10:00-10:30	**Coffee Break@ TROCADERO**

Session - 6

Session Chairs: **Prof. Gerard Mourou, Prof. Albert Fert, Prof. Manijeh Razeghi**
Video Presentation

Plenary Talk

10:30-11:10	**Prof. Alain Aspect Nobel Lecture, Institut d'Optique Graduate School / Université Paris-Saclay / École Polytechnique / Institut Polytechnique de Paris, France** Title: Single Photons, Entangled Photons: From Quantum Foundations to Quantum Technologies
11:10-12:00	**Prof. Leo Esaki, Prof. Albert Fert, Prof. Gerard Mourou and Prof. Manijeh Razeghi** Title: Discussion and future trends
12:00-13:30	**Lunch @PANORAMIC**

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DAY 02
WEDNESDAY, JUNE 28

Session - 7

Session Chairs: **Prof. Nader Engheta, Prof. Frederic Grillot**

Plenary Talk

13:30-14:00	**Prof. Eli Yablonovitch, University of California, USA** Title: Optical Physics Does Digital Optimization—which we call Onsager Computing for Machine Learning, Control Theory, Backpropagation, etc.
14:00-14:20	**Prof. Demetri Psaltis, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland** Title: Programming optical learning machines
14:20- 14:40	**Prof. Christophe Moser, Ecole Polytechnique Federale de Lausanne, (EPFL), Switzerland** Title: Nonlinear Processing with Only Linear Optics (nPOLO)
14:40-15:00	**Prof. Aydogan Ozcan, University of California, Los Angeles, USA** Title: Diffractive Optical Networks & Computational Imaging Without a Computer
15:00-15:30	**Coffee Break@ TROCADERO**

Session - 8

Session Chairs: **Prof. Selim Shahriar, Prof. Paul-Louis Meunier**

15:30-15:50	**Prof. Masud Mansuripur, The University of Arizona, USA** Title: Fundamental properties of beam-splitters in classical and quantum optics
15:50-16:10	**Prof. Frederic Grillot, Institut Polytechnique de Paris, France** Title: Secured free-space optics with mid-infrared quantum cascade lasers
16:10-16:30	**Prof. Yong Hang Zhang, Arizona State University, USA** Title: InAs/InAsSb type-II superlattice: Its material properties and applications in IR lasers and photodetectors
16:30-16:50	**Dr. Thierry Debuisschert, Thales Research & Technology, France** Title: Quantum sensing with ensembles of NV centers in diamond
16:50-17:10	**Prof. Arnaud Landragin, Sorbonne Université, France** Title: Quantum sensors with atomic interferometry
17:10-17:30	**Dr. Marina Yakovleva, Université Paris-Saclay, France** Title: Perfect coupling conditions for MIM antenna in zero magnetic field regions
17:30-17:50	**Dr. Yoshie Otake, RIKEN Center for Advanced Photonics, Japan** Title: RIKEN Accelerator-driven compact neutron sources, RANS, and their applications

END OF DAY 02

Hall Name: ETOILE LOUVRE

Session - 9

Session Chairs: **Prof. Christos Flytzanis, Prof. Jerzy M. Langer**

Plenary Talk

08:30-9:00	**Prof. Nader Engheta, University of Pennsylvania, USA** Title: Structuring Light with Metastructures
09:00-09:20	**Dr. Michel Krakowski, III-V Lab, France** Title: Highly stable DFB ridge laser diodes at 852nm and 894nm for Cesium atomic clocks
09:20-09:40	**Dr. Fabien Bretenaker, LuMin, Université Paris-Saclay, France** Title: Quantum Optics in a Metastable Helium Vapor
9:40-10:00	**Prof. Igor Zutic, University at Buffalo, USA** Title: Proximitized Quantum Materials: From Superconducting Spintronics to Majorana States
10:00-10:30	**Coffee Break@ TROCADERO**

Session - 10

Session Chairs: **Prof. Hooman Mohseni, Prof. Amr Helmy**

10:30-10:50	**Prof. Agnes Maitre, Sorbonne Université, France** Title: Dramatic acceleration and spectral broadening of CdSe /CdS single nanocrystal emission under high excitation or large confinement
10:50-11:10	**Prof. Giti Khodaparast, Virginia Tech, USA** Title: Optical Probe of Coherent States in Multi-Functional Materials
11:10- 11:30	**Prof. Yossi Paltiel, The Hebrew University, Israel** Title: Chiral molecules and the electron spin
11:30-11:50	**Dr. Olivier Acher, HORIBA France SAS, Palaiseau, France** Title: An in-plane position sensing technique with nm resolution based on machine vision: application to microscopy and laboratory activities
11:50-12:00	**Dr. Linda J. Olafsen, Baylor University, USA** Title: Quasi-Fermi Level Pinning and Optical Pumping Analysis toward Reduction of Droop in Interband Cascade Lasers
12:00-13:00	**Lunch @PANORAMIC**

International Conference On
Quantum Engineered Sensing And Information Technology

DAY 03
THURSDAY, JUNE 29

Session - 11

Session Chairs: **Prof. Hiroshi Ito, Prof. Eli Yablonovitch**

13:30-13:50	**Dr. Matthieu Dupont-Nivet, Thales Research and Technology, France** Title: Inertial Navigation with cold atom on chip
13:50-14:10	**Dr. Sebastien Bidault, Institut Langevin, ESPCI Paris, Université PSL, CNRS, Paris, France** Title: Purcell Effect in Plasmonic and Dielectric Resonators
14:10-14:30	**Dr. Yannick de Wilde, ESPCI Paris, PSL University, CNRS, Institut Langevin, France** Title: Probing the infrared thermal radiation of patch antennas
14:30- 14:50	**Dr. Nils C. Gerhardt, Ruhr-University Bochum, Germany** Title: Spin-Lasers: With Ultrafast Polarization Modulation to the Next Generation of Optical Communication Systems
14:50-15:00	**Dr. Paolo Rocchi, IBM and LUISS University, Italy** Title: An Engineering Theory of Sensing
15:00-15:30	**Coffee Break@ TROCADERO**

Session - 12

Session Chairs: **Dr. Binh-Minh Nguyen, Dr. Yannick de Wilde**

15:30-15:50	**Dr. John Prineas, University of Iowa, USA** Title: Purcell Effect versus Auger Scattering in Resonant Mid-Infrared W-Superlattice LEDs
15:50-16:10	**Prof. Joseph Tischler, University of Oklahoma, USA** Title: Hyperbolic Phonon Polaritons as a Route for Nanophotonic Devices
16:10-16:30	**Prof. Jeong Woo Han, Universität Duisburg-Essen, Germany** Title: Nonlinear THz absorption in graphene plasmons
16:30-16:50	**Prof. Mi Zetian, University of Michigan, USA** Title: Ferroelectric nitride semiconductors: Epitaxy, Quantum engineering, and emerging applications
16:50-17:10	**Prof. Maria Ines Amanti , Université Paris Diderot, France** Title: Generation and manipulation of frequency states of light with AlGaAs quantum sources
17:10-17:30	**Prof. Hiroshi Ito, The University of Tokyo, Japan** Title: Low-Noise Terahertz-Wave Detector: Fermi-Level Managed Barrier Diode
17:30-17:50	**Prof. Rui Q. Yang, University of Oklahoma, USA** Title: Recent Progress in Long Wavelength Interband Cascade Lasers
17:50-18:10	**Dr. Simeon I. Bogdanov, University of Illinois Urbana-Champaign, USA** Title: Ultrafast plasmon-enhanced deterministically assembled single-photon sources based on nanodiamond color centers

END OF DAY 03

Hall Name: ETOILE LOUVRE

Session - 13

Session Chairs: **Dr. Yoshie Otake, Prof. Simeon Bogdanov**

Plenary Talk

08:30-09:00	**Prof. Afshin Daryoush, Drexel University, USA** Title: Ultra-Broadband Compact Frequency Synthesizers Using Self-Forced Multi-Mode Multi-Quantum Semiconductor Lasers
09:00-09:20	**Prof. Lars Samuelson , Lund University, Sweden** Title: Realization of InGaN nanoLEDs delivering blue, green and red light
09:20-09:40	**Dr. Philippe Lalanne, CNRS-IOGS-University of Bordeaux, France** Title: Interaction of light with non-Hermitian plasmonic nanoresonators: The mode volume
09:40-10:00	**Prof. Hooman Mohseni, Northwestern University, USA** Title: Energy-Efficient Integrated Nano-Phototransistors
10:00-10:30	**Coffee Break@ TROCADERO**

Session - 14

Session Chairs: **Prof. Afshin Daryoush, Prof. Henri-Jean Drouhin**

10:30-10:50	**Dr. Yeshaiahu (shaya) Fainman, University of California San Diego, USA** Title: Nanoscale Light Emitters and their Dynamics
10:50-11:10	**Prof. Giuseppe Leo , Université de Paris - CNRS, Paris, France** Title: Second harmonic generation with wavefront control on dielectric metasurfaces
11:10-11:30	**Dr. Binh-Minh Nguyen, HRL Laboratories, LLC, USA** Title: Antimonide-based Narrow Bandgap Semiconductors for Infrared Technology and Quantum Information Science
11:30-11:50	**Dr. Jean-Francois Guillemoles, CNRS-Ecole Polytechnique/IPParis-ENSCP/PSL-IPVF/SAS, France** Title: Photovoltaic Conversion by Reciprocity
11:50-12:00	**Prof. Vijaysekhar Jayaraman, Praevium Research Inc., USA** Title: Detectors and Emitters for Mid-Wave Infrared Optical Communications
12:00-13:00	**Lunch @PANORAMIC**

Session - 15

Session Chairs: **Dr. Olivier Acher, Prof. Pedram Khalili**

13:30-13:50	**Prof. Clivia Sotomayor Torres, ICREA and Catalan Inst. Nanoscience and Nanotechnology, Spain** Title: Nanophotonics: from phonon confinement to topological protection

13:50 - 14:10	**Prof. Selim Shahriar, Northwestern University, USA** Title: Advanced Quantum Sensors: Superluminal Lasers, Subluminal Lasers and Schroedinger Cat Atomic Interferometers
14:10 - 14:30	**Dr. Murzy Jhabvala, NASA Goddard Space Flight Center, USA** Title: Overview of SLS-Based Instrument Development at NASA/Goddard Space Flight Center
14:30 - 14:50	**Dr. Luc Dame, Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS), IPSL/CNRS & University Paris-Saclay, France** Title: New Disruptive Solar-blind UVC Sensors for New Space Applications
14:50-15:00	**Dr. David Heydari, Stanford University, USA** Title: Electric-field induced nonlinear optics in CMOS silicon nanophotonic waveguides
15:00-15:30	**Coffee Break@ TROCADERO**

Session - 16

Session Chairs: **Prof. Giti Khodaparast, Prof. Linda J Olafsen**

15:30-15:50	**Dr. Maxime Oliva, Atos Quantum Lab, Atos, Les Clayes-Sous-Bois, Yvelines, France** Title: Towards Fermionic Systems Simulations on Quantum Computers with Myqlm-Fermion
15:50-16:10	**Dr. Bertels Koen, University of Ghent and QBee.eu, Belgium** Title: Quantum Computing Logic – an example for Quantum Genomics
16:10-16:30	**Dr. Mikhail Nestoklon, TU Dortmund, Germany** Title: Exciton Fine Structure in Lead Chalcogenide Quantum Dots: Interplay between Valley Mixing and Exchange Interaction
16:30-16:40	**Dr. Paola di Pietro, Elettra-Sincrotrone Trieste S. C. p. A., Italy** Title: Nonlinear ultrafast terahertz studies at the TeraFERMI beamline
16:40-16:50	**Dr. Amur Margaryan, A. I. Alikhanyan, National Science Laboratory, Armenia** Title: An advanced RF timer of single electrons and photons
16:50-17:10	**Dr. Chenzi Guo, CIOMP, Chinese Academy of Sciences, China** Title: To-tier resources: Light: Science & Applications, eLight and Light: Advanced Manufacturing

Poster Session Day 1-4 at AM-PM Break Timings

QUEST P-01	**Dr. Szymon Tofil, Kielce University of Technology, Poland** Title: Different Effects of Laser Removal of Coatings with Different Lasers Devices
QUEST P-02	**Dr. Kurp Piotr, Kielce University of Technology, Poland** Title: Mechanically Assisted Laser Forming of New Kind Helical Metal Expansion Joints
QUEST P-03	**Dr. Leonard Cardinale, University of Oxford, Oxford, UK** Title: Nuclear Spin Control in GaAs Quantum Dots via Nuclear Quadrupole Resonance

17:10-18:00 Conference Closing Ceremony and Group photo

DAY 1 | Session 1

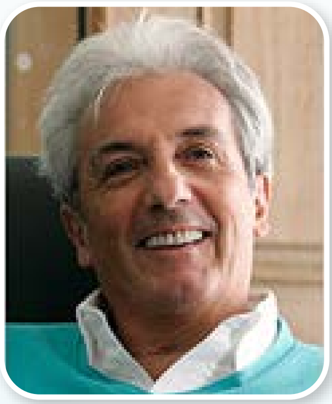
Conference Chairs:
Prof. Manijeh Razeghi, Prof. Leo Esaki, Prof. Klaus Von Klitzing

Plenary Session

Title: Spintronics: turning greener the digital technologies and far beyond with skyrmionics, neuromorphic nanochips or orbitronics
Prof. Albert Fert, UMR CNRS-THALES, Université Paris-Saclay

Title: Searching for Extreme Light
Prof. Gerard Mourou, École polytechnique Palaiseau, France

Spintronics: Turning greener the digital technologies and far beyond with skyrmionics, neuromorphic nanochips or orbitronics.



Albert Fert

UMR CNRS-Thales, Université Paris-Saclay, Palaiseau, France

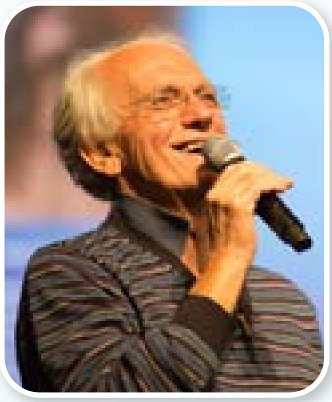
Abstract

Spintronics, the new type of electronics manipulating currents of spin instead of currents of charge, started with the discovery of the Giant Magnetoresistance (GMR) in 1988. After having boosted the technologies of information at the end of nineties, spintronics has now led to various applications. Today, the low power components called MRAM, on the marked since half-a-decade, are of high interest to turn greener the digital technologies and contribute to the reduction of their exploding energy consumption. Far beyond these current applications, spintronics opened the way to new fields of research such as skyrmionics, magnonics, neuromorphic nanochips and, more recently, orbitronics. I will focus on orbitronics which is based on the manipulation of orbit currents created by conversion from charge or spin current as well as by light or microwaves. Orbitronics can go beyond spintronics in term of efficiency but has also the interest of needing only very abundant elements.

Biography

Albert Fert, Ph.D. at Université de Paris, post-doc position in UK, became Professor at Université Paris-Sud in 1976. Albert Fert and the German physicist Peter Grünberg were jointly awarded the 2007 Nobel Prize in Physics for their independent discovery of the giant magnetoresistance (GMR) in 1988. This discovery kicked off the development of spintronics with several contributions coming from the joint laboratory of CNRS and company Thales that Fert cofounded. From 2007, Albert Fert is Emeritus Professor at Université Paris-Saclay and his team in the CNRS-Thales Laboratory developed pioneering works on skyrmions and topological electron gas. His recent works are on orbitronics and teraHz emission by orbitronics.

Searching for Extreme Light



Gerard Mourou

École polytechnique, Palaiseau, France

Abstract

Extreme-light laser is a universal source providing a vast range of high energy radiations and particles along with the highest field, highest pressure, temperature and acceleration. It offers the possibility to shed light on some of the remaining unanswered questions in fundamental physics like the genesis of cosmic rays with energies in excess of 1020 eV or the loss of information in black-holes. Using wake-field acceleration some of these fundamental questions could be studied in the laboratory. In addition extreme-light makes possible the study of the structure of vacuum and particle production in "empty" space which is one of the field's ultimate goal, reaching into the fundamental QED and possibly QCD regimes. Looking beyond today's intensity horizon, we will introduce a new concept that could make possible the generation of attosecond-zeptosecond high energy coherent pulse, de facto in x-ray domain, opening at the Schwinger level, the zettawatt, and PeV regime; the next chapter of lasermatter interaction.

Biography

Gérard Mourou is Professor Haut-Collège at the École polytechnique. He is also the A.D. Moore Distinguished University Emeritus Professor of the University of Michigan. He received his undergraduate education at the University of Grenoble (1967) and his Ph.D. from University Paris VI in 1973. He has made numerous contributions to the field of ultrafast lasers, high-speed electronics, and medicine. But, his most important invention, demonstrated with his student Donna Strickland while at the University of Rochester (N.Y.), is the laser amplification technique known as Chirped Pulse Amplification (CPA), universally used today. CPA revolutionized the field of optics, opening new branches like attosecond pulse generation, Nonlinear QED, compact particle accelerators. It extended the field of optics to nuclear and particle physics. In 2005, Prof. Mourou proposed a new infrastructure ; the Extreme Light Infrastructure (ELI), which is distributed over three pillars located in Czech Republic, Romania, and Hungary. Prof. Mourou also pioneered the field of femtosecond ophthalmology that relies on a CPA femtosecond laser for precise myopia corrections and corneal transplants. Over a million such procedures are now performed annually. Prof. Mourou is member of the U.S. National Academy of Engineering, and a foreign member of the Russian Science Academy, the Austrian Sciences Academy, and the Lombardy Academy for Sciences and Letters. He is Chevalier de la Légion d'honneur and was awarded the 2018 Nobel Prize in Physics with his former student Donna Strickland.

DAY 1 | Session 2

Session Chairs:
Dr. Martin Defour, Dr. Ferechteh Hosseini Teherani

Plenary Session

History and Example of achievement with Gallium Oxide Based Space Electronics
Dr. F.H. Teherani, Nanovation, France

Title: Historical information about, Thomson CSF, Thales , and QUEST conference
Dr. Jean-Pierre Huignard, Prof. Paul-Louis Meunier and Prof. Manijeh Razeghi

Title: The second Quantum Revolution from an industrial Perspective
Dr. Bernhard Quendt, Chief Technical Officer, Thales, France

Title: European Innovation Council -A star in the making
Prof. Jerzy M. Langer, Warsaw Scientific Society, Poland

Dr. DEFOUR Martin

Chief Technical Officer, Defence Mission Systems
THALES Research Group, France

Biography

Martin joined Thales in 1986 at the Corporate Research Laboratories. He is in charge of the growth and characterisation of III-V semiconductor materials for microwave and laser devices. In 1990, he joined the Technical Directorate of the Thales Optronics Division, in charge of advanced studies on technologies for Laser Counter Measure applications. During that same period, he was head of the design department for optronic solutions, such as a new optical reconnaissance pod, a laser designation targeting pod for combat aircraft and identification and the laser range finding integrated into the Rafale.

In 2000, he became Vice-President, Chief Technical Officer of the Aerospace Division (covering both civilian and military activities) with activities in Avionics Systems, Flight Management Systems, Mission Systems for Military Aircrafts and UAVs, Surveillance and Combat Radars, Aircrafts and Naval Electronic Warfare Systems. Since 2010, Martin has been VP, Chief Technical Officer of the Thales Defence Mission Systems Global Business Unit.

He is in charge of Design Authority, Technical Strategy, R&T and Engineering governance. As such, he covers the following activities: radar systems and countermeasures for combat aircraft, in particular for the Rafale, but also for upgrade programsme, manned and unmanned ISR Systems, airborne maritime patrol and surveillance systems, airborne surveillance radars and associated electronic warfare sub-systems, Electronic Intelligence (ELINT), Signal Intelligence (SIGINT) and sonars for all platforms (submarines, surface ships, helicopters and maritime patrol aircraft), mine countermeasures systems, acoustic homing heads for torpedoes, and tactical and other critical systems for surface vessels.

Martin has been awarded the French Aeronautics Medal. He is the author of more than 30 publications, and holds 30 patents in the field of semiconductor physics, photonics, microwaves and optics or electromagnetics solutions. He is the Thales board member at United Monolithic Semiconductors. Martin graduated as an Engineer from the Ecole Normale Supérieure and, simultaneously, as the holder of a PhD in Atomic and Molecular Physics, jointly, and as a physics professor.

History and Example of achievement with Gallium Oxide Based Space Electronics

F. H. Teherani[1*]

[1]Nanovation, 8 route de Chevreuse, 78117 Châteaufort, France

Abstract

Gallium oxide (Ga_2O_3) is an ultra wide bandgap (Eg = 4.9 eV) semiconductor, which has attracted great interest for this material due to a set of distinctive properties for use in deep-UV optoelectronics, LEDs, radiation detection and gas sensing devices. A number of recent breakthroughs, including the growth of relatively large single-crystal substrates (up to 6 inches in diameter) and the demonstration of tunable n-type doping with reasonably high mobilities [1] have been reported. With regards to space applications, Ga_2O_3-based photodetectors have emerged as promising candidates to overcome current technological limits for UVC detection. Indeed, space-based monitoring of UVC solar radiation, and, more specifically, the Herzberg continuum (200-242nm), is fundamental to understand its' impact on the earth's climate and build better chemistry-climate models [2]. It is also, however, extremely challenging to achieve due to the harsh operating environment including large thermal variations, high energy particles, ionizing radiation and filter contamination due to satellite outgassing. Ga_2O_3 is a good fit to these challenges because it is intrinsically solar blind, extremely radiation-hard, thermally-robust. The authors have recently shown that Ga2O3's bandgap can be engineered upwards through Al alloying so as to obtain optical responses down to 200nm [3,6] – see Figures 1 and 2. Here, we will show the result of a successful technological roadmap with the launch into space on the INSPIRE-Sat 7 cube sat of a 220nm Ga_2O_3-based photodetector developed by Nanovation. This deployment represents an important milestone and could be the precursor of commercial applications for Ga_2O_3 (both spatial and terrestrial).

[1] M Razeghi et al Proc SPIE 10533 (2018) R-1 [2] M Meftah et al Remote Sensing, 12(1), (2020) 92. [3] D Rogers et al Proc SPIE 11687 (2021) 2D-1 [4] M Meftah et al Remote Sensing, 13(8), (2021) 1449 [5] X Arrateig et al Proc SPIE 11858 (2021) 13-1 [6] L Dame et al Proc SPIE (2023) 1242207-1

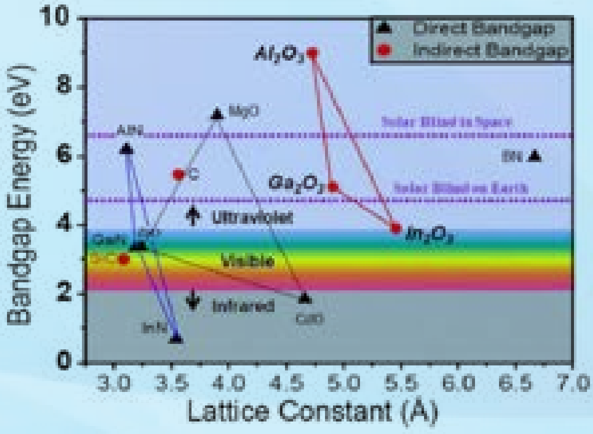


Fig. 1 Illustration of the bandgap engineering range possible with β-Ga_2O_3 (through addition of In or Al) in contrast to the possibilities offered by alternative WBG and UWBG semiconductors [1].

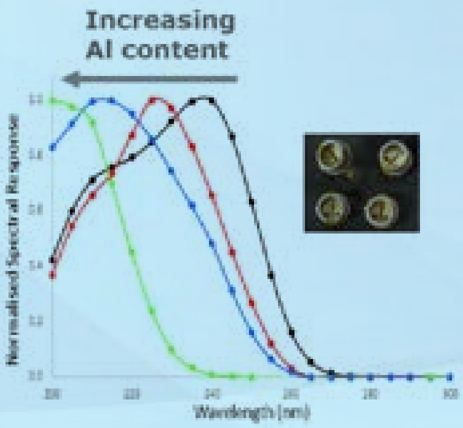


Fig. 2 Normalised spectral response of β-(Al)Ga_2O_3 photodetectors showing that peak position can be tuned from 200 to 240nm through Al content control.

Biography

Dr Ferechteh H. Teherani : has been involved with the development of novel oxide materials and devices for 30 years. After receiving her PhD from University of Paris Saclay, Dr Teherani was a researcher at Thales & SUPELEC (France), NTT (Japan), Electrotechnical Laboratory (Japan) and Northwestern University (USA). In 2001, she went on to found a startup, Nanovation of which she is currently CEO. Nanovation develops and commercializes oxides materials such as ZnO, Ga2O3 & NiO thin films and nanostructures for optoelectonic applications. Dr Teherani also has an MBA, has held an Escbach Visiting Scholarship at Northwestern University and has been an expert for the European Commission since 2005. Dr Teherani is author/co/author of over 150 papers and 19 patents.

From QUEST 2020 to QUEST 2023 … How relativity fits Quantum mechanics

Prof. Paul-Louis Meunier

ESTP-Paris, France

Abstract

Initiated in August 2020, Prof. Razeghi and her fellow colleagues gathered the best Academic and Industrial Quantum experts for the conference. The committee picked the "Pierre & Marie Curie" early laboratory in Paris as the place to listen the latest outstanding progress in the quantum mechanics physics…

Strike in the "Blue Sky" the COVID 19 Pandemic shows up…QUEST is postponed!

To make the long story short, each speaker, each material organization member had to be kept care for the next conference. In 2022, the Pandemic slows down and hope to have the conference, hosted by Ecole Polytechnique France, becomes a reality. Organization committee "on the loom hands over his work" …

Strike in the "Blue Sky", February 2022 war at the border of Europe shakes the travelling security network…QUEST is postponed!

At last, in 2023, the international problems slacken, the worldwide community reconvenes and breathes bold and innovative air. Time elapsed as relativity quotes, and gathered in Paris this June 2023, we will express the best Quantic applications hope for the next decade to Humanity. Warmest thanks to the soul of QUEST: Pr. Manijeh Razeghi.

Biography

Pr. Paul-Louis Meunier dedicated his professional life to Research and Innovation. He joined LCR (THOMSON-CSF) in 1980 for a ten year research period successfully working LPE growth and characterization of nano materials owning Piezoelectric - Magnetooptical physical properties for Gbit/s Telecom and Hi-density data recording. Then he joined the Worldwide THOMSON Multimedia Innovation dealing with HDTV- TV Memory- e-Book and glassless 3DTV…Paul-Louis filed more than three hundred patents and published numerous articles. He always monitored Industrial and Academic life aside and teaches Research & Physics at ESTP-Paris (Paris-Est Univ.) and carries out top notch research program. He is graduated from Ecole Supérieure d'Electricité (Paris Saclay Univ.) and got Material Science PhD at Paris-Est University. He is member of the European Interdisciplinary Sciences Academy.

History of THOMSON-CSF LCR

Dr. Jean-Pierre Huignard

France

Abstract

The CSF - Compagnie Générale de Télégraphie Sans Fil 1950's – was a French leading company for the development of advanced Sciences and Technologies in the fields of Microwaves, Radars, Communications and Signal processing. His research laboratories where established in the park of the Castle of Corbeville, a very pleasant location at 25 km south part of Paris. The Research Lab was intended to propose original ideas and experimental demonstrations of novel communications systems and on the physics of very frequency waves, for example microwaves tubes, and low loss dielectric waveguides. These achievements in microwaves very much inspired the start of research in the 1960s on lasers and optoelectronics at the Central Research Lab (LCR). As example the first experiments for guiding laser light in single mode fibers where early proposed and demonstrated at LCR as well as other outstanding research works on a diversity of subjects as: Solid state lasers, nonlinear optics, guided wave optics, holography and signal processing, liquid crystal display, semiconductor physics and devices for photon emission and detection. A special mention to a very innovative project demonstrating in the mid-1970s , the TH-CSF Videodisc where the video signal was optically recorded and readout as micro pits on a flexible transparent polymer disc. Then novel breakthroughs in the years 1980 and later, in the MOCVD quantum technologies pioneered by Prof. Manijeh Razeghi thus demonstrating very high quality epitaxial and hetero epitaxial semi-conductor layers thus leading to first outstanding performances of quantum semiconductor lasers and detectors. These remarkable scientific achievements of LCR where very much inspired and supported by the TH-CSF LCR Director Erich Spitz and by Prof Pierre Algrain Chief Scientific Officer THOMSON-CSF who quoted to Prof. Manijeh Razeghi that the future of telecom would be optical and who also became Minister of Research (78-81).

Biography

Jean-Pierre Huignard received his Engineering-Master and PhD Degrees from the – Institutd'Optique Graduate School and University Paris-Saclay. He was head of the optics and signal processing lab at THOMSON - CSF Research labs LCR and then he had the position of Senior Scientist at THALES Research and Technology Fr (new name of TH-CSF - LCR). He is now invited Member of the Institut Langevin-University Paris. Main research activities and fields of expertise are: diffractive optics and nanostructures, coherent imaging, lasers and nonlinear optics, microwave optics and optoelectronic signal processing. JP Huignard organized and chaired the CLEO Conferences. He is coeditor of several books and author of book chapters in photorefractive nonlinear optics, phase conjugation, optical signal processing. He is Fellow Member of the OSA - E Leith Prize of the OSA 2011 – L Brillouin Prize of the SFO 2015.

The second Quantum Revolution from an industrial Perspective

Bernhard Quendt

Chief Technical Officer, Thales, France

Abstract

The second Quantum revolution is paving the way to new devices and systems, therefore new usages and business models that will impact and often disrupt many industrial sectors. Anticipating and managing the transition is therefore crucial and asks for several actions in parallel. Starting from being part of the research community is a must, but is not enough - one must think about use cases rather than solutions, and compare the various technological options offered by the dynamic academic community. Another challenge is the need to discover, learn and grow at scale the technical knowledge on adjacent technical fields; if quantum programming has been already identified as a necessary field of expertise as a complement to quantum computers, the same is needed for Quantum Communication networking, Quantum Signal processing, Quantum based electronics.

Biography

Dr. Bernhard Quendt holds engineering degrees from the University of Stuttgart and Télécom Paris (ENST), and completed a PhD at the Technical University of Munich, where he was awarded the Rohde & Schwarz Prize. Formerly Chief Technical Officer for Siemens Digital Industries, Dr. Bernhard Quendt joined the Siemens Communications division in 1999 before being appointed Vice President R& D for Siemens Rail Automation in 2005. In 2011 he took the responsibility for platform activities and R& D as Vice President for Siemens Industrial Automation Systems and since 2015, he held the position of the Chief Technical Officer at Siemens Digital Industries. Bernhard Quendt joined Thales in 2020 as Chief Technical Officer and Senior Vice President.

European Innovation Council -A star in the making

Jerzy M. Langer

President, Warsaw Scientific Society, Warsaw, Poland

Abstract

After several years of preparatory activity and most successful EIC-Pilot exercise, at the beginning of 2021 the European Innovation Council (EIC) was launched with impressive 10 bln EUR budget. The EIC, being a part of Horizon Europe, aims to identify and support breakthrough technologies and game changing innovations to create new markets and scale up internationally. The research pilar of the EIC is the PATHFINDER program based upon most successful Future Emerging Technologies (FET) program, while the ACCELERATOR will be the commercialisation pillar of the EIT designed to support most innovative and perspective European SMEs. Both pillars are interconnected by a variety of TRANSITION actions ranging from extra financial input, through mentoring and linking to already established businesses and venture capital. A major novelty is the direct involvement of the EIC executive agency responsible for the EIC by a direct investment (equities and loans) and active support and mentoring topping the well-established grant system. Also, a top-down element (thematic calls) is sought of. The expected key features of the EIC will be simplicity of submissions, agility and friendliness. Also, the EIC will actively pursue support of innovative initiative in less developed regions of Europe (Seal of Excellence actions) as well as greater involvement of female researchers and innovators. A massive interest in both Pathfinder and Accelerator strands of the EIC Pilot exercise unequivocally proved the need of such a grand pro-innovation program at the EU level. The target groups of the EIC are breakthrough-technologies-oriented research teams and innovative SMEs. Thus, the complementary trio consisting of the European Research Council, Maria Sklodowska-Curie Fellowship scheme and the EIC, addressing most talented and entrepreneurial Europeans, should soon become a major tool in regaining Europe's top position among the driving forces of the future.

Biography

Emeritus professor of physics (working until 2017 at Inst Phys. Polish Academy of Sciences), specializing in physics of defects, junctions and recombination processes in solids. Elected Fellow of the American Physical Society and Academia Europaea. President of Warsaw Science Society. Headed ERC Advanced Grant panel in condensed matter. Co-author of key European policy documents related to R&D and regional innovation policies of the EU. Member of several R&D advisory bodies to the European Commission, recently as a FET-AG chair and EIC-AG. Conducted, and coordinated analysis to underpin the EIC and the ERC and formulated concept of the FET-based EIC (2011).

DAY 1 | Session 3

Session Chairs:
Prof. Dr. Wolfgang Elaesser, Prof. Yeshiahu Fainman

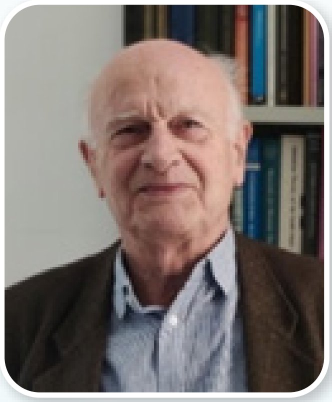
Title: Fashioning and Pumping up the Sound. Photodriven Coherent THz Acoustic Phonon Amplification and Quantum Cascade Saser Operation in Semiconductor Superlattices
Prof. Christos Flytzanis, Ecole Normale Supérieure, France

Title: Semiconductor Circuits for Quantum Enhanced LIDAR Systems
Prof. Amr Helmy, University of Toronto, Canada

Title: Ultra-narrow linewidth self-adaptive photonic oscillator: From principle to product
Prof. Mehdi Alouini, Institut Foton, UNIVREN/CNRS, Rennes, France

Title: Spintronic Phenomena for Reversible, Neuromorphic, and Reservoir Computing
Prof. Joseph Friedman, The University of Texas at Dallas, USA

Fashioning and Pumping up the Sound. Photodriven Coherent THz Acoustic Phonon Amplification and Quantum Cascade Saser Operation in Semiconductor Superlattices



[1]K.Shinokita, [1]K. Reimann, [1]M. Woerner, [1]T. Elsaesser, [2]R.Hey, [3]**C. Flytzanis**

[1]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie,12489 Berlin, Germany

[2]Paul-Drude-Institut für Festkörperelektronik, 10117 Berlin, Germany

[3]Laboratoire de Physique, Ecole Normale Supérieure, Paris 75231 Paris Cedex 05, France

Abstract

The generation and amplification of pulsed beams of coherent acoustic phonons with well prescribed spatiotemporal characteristics is a central issue in the growing field of phononics. In this respect the transfer of concepts and schemes from the field of nonlinear optics, photonics and optoelectronics is of central importance.

We present and demonstrate a novel concept and scheme of acoustic phonon amplification at sub-THz frequency and a few nanometers wavelength range based on the photodriven *acoustoelectric* (AE) effect with 100fs light pulses in an electrically biased semiconductor superlattice (SL) GaAs/AlGaAs; the amplification is due to stimulated Cerenkov *folded zone ac-phonon* emission by electrons undergoing intra-miniband transport. The process is accounted for with a detailed theoretical model and extensions are discussed.

With appropriate phononic microcavity configuration it can allow the realization of the *SASER (Sound Amplification by Stimulated Emission of Radiation)* operation the analogue of the *Laser* with sound. In the present configuration it is the analogue of the quantum cascade laser with sound in the sub-THz frequency and a few nm wavelength range. Such a coherent phonon source allows for investigations with very high spatial resolution, almost comparable to that of an electron microscope, e.g. in microelectronic devices or in microbiology.

Biography

Studies: M. Eng (Civ Eng) Technical Physics 1964, Royal Institute of Technology (KTH), Stockholm, Sweden

DEA Quantum Physics 1966, ENS/Uni of Paris, Paris, France

D. Sc 1970, Uni of Paris Orsay, supervised by Prof Jacques Ducuing, Lab d'Optique Quantique (LOQ- CNRS).

Positions: Joins CNRS 1969 in LOQ-CNRS, Ecole Polytechnique, Palaiseau, France; Research Director and Director of LOQ-CNRS 1982; moves 2000 to the Physics Department, Ecole Normale Supérieure, Paris, France.

Joint appointments: Research Associate, Harvard Uni 1970-72, Cambridge, USA.

A von Humboldt Fellow 1985, Max Plank Inst Quantum Optics, Munich, and Max Born Inst, Berlin, Germany.

Miller Fellow 2000 Physics Department, Uni California, Berkeley, California, USA.

Williams Chalmers Guest Professor 2001-07, Applied Physics, Chalmers Technical Uni, Göteborg, Sweden.

Guest Exchange Prof ENS-SYSU 2010-16, Sun Yat Sen Uni, Guangzhou, China.

QUEST 2023

Semiconductor Circuits for Quantum Enhanced LIDAR Systems

Amr S. Helmy

Univeristy of Toronto, Canada

Abstract

The detection of objects under large background conditions is a problem of fundamental interest in sensing. In this talk we routes of enhancements of classical target detection protocols, using quantum correlations obtained from practical non-classical semiconductor photon sources. As a comparison to the quantum enhancements obtained in the detection protocols obtained by utilizing such sources we also consider a classical phase- insensitive target detection protocols. We carry out experiments using a our semiconductor sources. The experimental results agree very well with the theoretical prediction. In particular, we find that in a high-level environment noise and loss, the quantum enhancement is readily achievable when compared to classical protocol target detection performance but with 10-100 fold lower time for target detection. Furthermore, unlike classical target detection and ranging protocol, the probe photons in quantum-enhanced target detection are completely indistinguishable from the background noise and are therefore useful for covert ranging applications. Finally, our technological platform is highly scalable and tunable and thus amenable to large scale integration necessary for practical applications.

Biography

Amr is a Professor in the department of electrical and computer engineering at the University of Toronto. Prior to his academic career, he held a position at Agilent Technologies, R&D division, in the UK between 2000 and 2004. At Agilent his responsibilities included developing InP-based photonic semiconductor integrated circuits and high-powered submarine-class 980 nm pump lasers. He received his Ph.D. and M.Sc. from the University of Glasgow with a focus on photonic devices and fabrication technologies, in 1999 and 1995 respectively. He received his B.Sc. from Cairo University in 1993, in electronics and telecommunications engineering science. His research interests include photonic device physics and characterization techniques, with emphasis on nonlinear optics in III-V semiconductors; applied optical spectroscopy in III-V optoelectronic devices and materials; III-V fabrication and monolithic integration techniques. Amr has served the community in numerous roles. He has served as Vice President Membership for the IEEE Photonics Society (2008-2010). He is currently the CLEO Program Chair (2018-2020), where he previously served as the chair for the Semiconductor Lasers committee. He also serves as the Technical Program Chair for IPC 2016-2018, where he previously served as the chair for the committees on Semiconductor Lasers, Optical Materials and Metamaterials as well as the committees on Photonic Integration and Packaging. He has served as an associate editor for the Photonics Journal and is currently an associate editor for Optics Express.

Ultra-narrow linewidth self-adaptive photonic oscillator: From principle to product

Mehdi Alouini

Institut Foton, UNIVREN/CNRS, Rennes, France

Abstract

Highly coherent laser sources are mandatory for a wide field of applications among which microwave photonics, time-frequency domain metrology, atom manipulation, atomic clocks, high-resolution spectral analysis, lidar, long-haul sensing, gravitational wave detection, quantum optics, and more generally in research involving light-matter interactions. Over the past decennia, a sustained scientific effort has been made to develop such highly coherent optical sources including quite cumbersome optical references, smart phase-locking loops and noise reduction electronics. These approaches rely on a common paradigm consisting in struggling against the frequency noise of the laser source rather than envisioning a system that naturally relaxes towards a stable narrow linewidth operation. We have proposed and demonstrated a new general principle leading to such a natural relaxation. It relies on two nested fiber active resonators mutually resonant to each other by construction. The high spectral purity is given by the longest active resonator (100m-long) in which Stimulated Brillouin Scattering is employed to ensure at the same time optical gain, frequency self-matching of the gain maximum and single frequency operation. This high-Q active resonator is made non-reciprocal so that it has a resonant behavior for the Stokes wave and a non-resonant one for the pump wave, releasing the need of a narrow linewidth pump and frequency locking electronics. Part of the stokes wave is frequency up-converted, and optically fed back to the semiconductor laser pump. As the pump acquires the spectral purity of the Stokes wave a cascade mechanism occurs where the Stimulated Brillouin Scattering becomes more and more efficient leading to a self-linewidth narrowing which ends up with natural linewidth of a few tens of millihertz. The long-term drift of such photonic oscillator is within 10 MHz over hours without any servo locking or stabilization electronics. A proof of concept conducted at 800 nm confirms that this principle can be tailored to any wavelength within reach of semiconductor lasers, which opens tremendous opportunities in particular in quantum optics.

Biography

Pr. Mehdi Alouini received the M.S. degree in Optics and Photonics from Université de Paris XI, Orsay, in 1997. After having graduated from Ecole Supérieure d'Optique, Orsay, he received the Ph.D. degree in laser physics from Université de Rennes in 2001. He was with Thales Research and Technology, Palaiseau, as research scientist from 2001 to 2009. Since then, he joined Université de Rennes where he led the Optics and Photonics Department of Institut de Physique de Rennes up to 2017. He was deputy director of Institut Foton from 2017 to 2021 and now its director. His research activities cover microwave photonics, advanced imaging, and laser physics. He holds 12 patents and he authored or coauthored 132 papers in peer reviewed journals and more than 200 communications.

Spintronic Phenomena for Reversible, Neuromorphic, and Reservoir Computing

Joseph S. Friedman

Electrical and Computer Engineering, The University of Texas at Dallas, Richardson, TX, USA

Abstract

The rich physics present in a wide range of spintronic materials and devices provide opportunities for a variety of computing applications. This presentation will overview four distinct proposals to leverage spintronic phenomena for reversible computing, neuromorphic computing, and reservoir computing. The presentation will begin with a solution for reversible computing in which magnetic skyrmions propagate and interact in a scalable system with the potential for energy dissipation below the Landauer limit. Two neuromorphic systems for emulating neurobiological behavior with spintronic phenomena will then be presented: a purely-spintronic system that enables unsupervised learning with magnetic domain wall neurons and synapses, and an approach for unsupervised learning that marks the first experimental demonstration of a neuromorphic network directly implemented with MTJ synapses. This presentation will conclude with a reservoir computing system based on the dynamics of irregular arrays of frustrated nanomagnets that increases overall hardware efficiency by a factor of 10,000,000.

Biography

Dr. Joseph S. Friedman is an associate professor of Electrical & Computer Engineering at The University of Texas at Dallas and director of the NeuroSpinCompute Laboratory. He holds a Ph.D. and M.S. in Electrical & Computer Engineering from Northwestern University and undergraduate degrees from Dartmouth College. He was previously a CNRS Research Associate with Université Paris-Saclay, a Summer Faculty Fellow at the U.S. Air Force Research Laboratory, a Visiting Professor at Politecnico di Torino, a Guest Scientist at RWTH Aachen University, and worked on logic design automation at Intel Corporation. He has also been awarded the NSF CAREER award.

DAY 1 | Session 4

Session Chairs:
Prof. Masud Mansuripur, Prof. Yossi Paltiel

Title: Space based quantum communications at Airbus
Dr. Andrew Thain, Space Systems, AIRBUS, Toulouse, France

Title: Ultrafast spin-charge conversion in topological insulators surface states probed by THz emission spectroscopy
Dr. Henri Jaffres, Université Paris-Saclay, Palaiseau, France

Title: Terahertz Emission Spectroscopy and Imaging of Semiconductor Heterostructures and Quantum Wells
Dr. Tonouchi Masayoshi, Osaka University, Japan

Title: Phase-change Materials for Reconfigurable Metaphotonics
Prof. Ali Adibi, Georgia Institute of Technology, USA

Title: Giant Control of GHz-THz Nonlinearities in Semiconductor Superlattices
Prof. Mauro Pereira, Khalifa University of Science and Technology, UAE

Title: An operational, real-field, entanglement-based quantum key distribution network
Dr. Sébastien Tanzilli, CNRS, Université Côte d'Azur, Institut de Physique de Nice, France

Title: Polaritonic Nonlinear Metasurfaces for Flat Nonlinear Optics in Mid- and Far-Infrared
Dr. Mikhail Belkin, Technical University of Munich, Germany

Space based quantum communications at Airbus

[1]Andrew Thain and [2]Matthieu Dollon
[1,2]Space Systems, AIRBUS, Toulouse, France

Abstract

AIRBUS has been highly active in the area of quantum communications from space. In this talk we present how heritage developments in classical laser communications and agile Earth Observation satellites can provide services with sufficient capacity to be exploitable for practical use-cases. We will show our latest satellite designs and their application for Prepare and Measure Quantum Key Distribution (PM-QKD), Entanglement Based QKD (EB-QKD) as well as Quantum Information Network (QIN) applications. We illustrate how our developments of large aperture optical space terminals (possessing telescope diameters of up to 50 cm) not only have a significant impact on QKD key generation rates, but they also allow a greatly simplified user segment.

We show the importance of correctly characterising environmental impairments to such protocols and how end-to-end services can be characterised and optimised by detailed modelling of all parts in the system, from the components of the quantum links right up to the algorithms governing the scheduling of the satellite constellations.

Lastly, we present our roadmap to offer an operational system by 2027, and the key demonstration phases to get there. We underline that such development phases, which will include the implementation of demonstration missions, also offer an excellent opportunity for collaborations with the physics community and we encourage proposals to benefit from such a unique opportunity for pure and applied physics experiments.

Biography

Dr Andrew Thain graduated with a 1st class BSc hon physics degree at Bristol University. He continued with a Ph.D. exploring Quantum Oscillations in Heavy Fermion systems, developing a SQUID based magnetometer operating in mK temperatures in 20T magnetic fields. This experimental work was followed by a theoretical physics post-doc in the Bristol Physical-Asymptotics team, working in the area of diffractive contributions to quantum chaos.

He has since pursued a career in industry, at the research centres of BAe Systems, AIRBUS and latterly at AIRBUS Space Systems. His activities have covered mathematical modelling, numerical simulation, electromagnetic propagation, antenna design, stealth, Instrument Landing Systems, EMC, photonics, wireless and wired networks. He has been working on Quantum Key Distribution since 2014 leading several EU and ESA projects, and is the AIRBUS Expert on Quantum Communications and Quantum Information Systems.

Matthieu Dollon has been working for introducing new technologies in satellites for more than 20 years. In 2019 he started to build the quantum communication program in Airbus, starting from academic partnerships, Airbus laboratory demos and first system sketches, with the objective to make it an operational system within the decade.

Before this Matthieu has been leading innovation in several domains, with successes such as : The space optical fiber gyro family Astrix, the first COTS FPGA for class 1 satellites, concluding partnership for the electronic of the Carmat heart prosthesis, preparing the development of the NanoExplore NG-Ultra, the first high performing HiRel European SoC.

Innovation is his motto, linking technology experts, financers and users to bring technologies from laboratories to applications, bridging the TRL valley of death. Matthieu is graduated ISAE-Supaero in 1990.

Ultrafast spin-charge conversion in topological insulators surface states probed by THz emission spectroscopy

[1]Henri Jaffrès, [2]E. Rongione1, [3]L. Baringthon1, [4]S. Fragkos, [4]P. Tsipas, [2]J. Hawecker, [1]T.- H. Dang, [4]E. Xenogiannopoulou, [3]P. Lefèvre, N. Reyren1, [5]G. Patriarche, [5]A. Lemaître, [4]A. Dimoulas, 1R. Lebrun, [1]J.-M. George, [2]S. Dhillon

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[2]Laboratoire de Physique de l'Ecole Normale Supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université de Paris, F-75005 Paris, France

[3]Synchrotron SOLEIL, Cassiopée beamline, F-91190 Saint-Aubin, France

[4]Institute of Nanoscience and Nanotechnology, National Center for Scientific Research "Demokritos," G-15310 Athens, Greece

[5]Université Paris-Saclay, CNRS, Centre de Nanosciences et de Nanotechnologies, F-91120 Palaiseau, France

Abstract

Spin-charge conversion (SCC) by inverse spin Hall and/or inverse Rashba-Edelstein effects at the interface of heavy metals or topological insulators (TIs) and involving high spin-orbit interactions are of a prime importance for today's spintronics and its applications e. g. using spin-orbit torque functionalities. In that prospect, THz emission spectroscopy can offer a very reliable probe to investigate ultrafast spin and charge currents to probe the spin-injection efficiency in devices. Systems either consist in nanometer-thin multilayers composed by a ferromagnetic (FM) layer and a heavy metal (HM) from the 3d-5d family giving rise to SHE with engineered interfaces. Alternative path for spin-orbit torque technologies now turns to bilayers of FM and topological insulator (TI). TIs present conductive topological surface states (TSS) which allow interfacial SCC via the inverse Rashba-Edelstein effect (IREE). In this study, we demonstrate large ultrafast spin-charge interconversion and THz emission using the TSS of Bi1-xSbx and Bi2SnTe4 TI quantum interfaces. We will report on THz emission features from dynamical spin-injection in Bi0.79Sb0.21(15nm) and Bi2SnTe4(5SL). Stoichiometry of Bi2SnTe4 has been chosen to minimize the presence of bulk bands at the Fermi crossing contrary to other Bi-based TIs such as Bi2Se3. Emission performances of Bi0.79Sb0.21 and Bi2SnTe4 are about the same order of magnitude as Co/Pt state-of-the-art spintronic THz emitters. Moreover, thickness-independent renormalized emission is demonstrated on Bi2SnTe4 is in favor of an interfacial SCC carried by IREE.

Biography

Dr. Henri Jaffrès is senior researcher at CNRS UMPHY Cnrs-Thales, University Paris-Saclay and graduated from the Institut National des Science Appliquées, Toulouse III since 1995. He received his PhD from the same university in 1999 in the thematics of spintronics and thin magnetic films. He joined as Post-Doc the CNRS-UMPHY Cnrs-Thales in 1999 before being recruited in 2001 as a CNRS staff. His work consists in the study of spin-Hall effects and Rashba-Edelstein effects in metallic systems and semiconductors. During the 2010's, he worked out on several ANR program (ANR SOSPIN, ANR SiGeSPIN, ANR TOPRISE) and on European FET-OPEN program s-Nebula (2020-2024). He is now assistant professor at Ecole Polytechnique Palaiseau from 2017.

Terahertz Emission Spectroscopy and Imaging of Semiconductor Heterostructures and Quantum Wells

Masayoshi Tonouchi

Institute of Laser Engineering, Osaka University, Suita, Osaka Japan

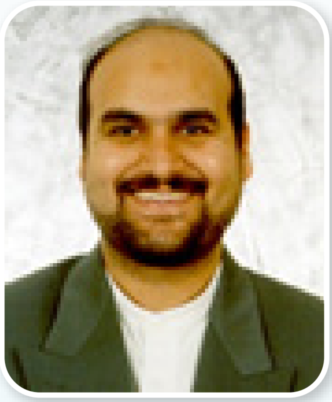
Abstract

We apply terahertz (THz) emission spectroscopy and microscopy to investigate the ultrafast spatiotemporal photocarrier transfer in semiconductor heterostructures and quantum wells. The photocarriers excited with a femtosecond laser are accelerated by built-in fields and/or travel ballistically, resulting in inducing photocurrents. The THz waves are emitted in proportion to the time derivative of the photocurrent, and the emission waveforms monitored in time-domain reflect their ultrafast dynamics responses nearby the excitation spots. In this presentation, we explain those behaviors with a simple model with some examples. The examples are Si-MOS, GaN heterostructure high-mobility-electron transistor (FET), Al0.3Ga0.7N/GaN high-electron-mobility transistor (HEMT), GaInN/GaN multiple quantum wells (MQWs), so on. In the Si-MOS, we can understand how the emission properties depend on the parameters such as the surface potential, the relative permittivity of passivation layers, the defects in bith the passivation and semiconductor. The interesting emission futures are seen in the emission properties from GaInN/GaN MQWs, which consist of the multi-physical mechanisms; (i) laser-induced ultrafast dynamical screening of built-in bias electric field in MQWs followed by (ii) capacitive charge oscillation of the excited carriers, and (iii) the coherent acoustic phonon (CAP)-driven polarization surge at the discontinuity between the GaN capping layer and air. Based on the observation, applications to the material parameter extraction and nano-seismology in non-contact and non-destructive manner will be discussed.

Biography

Masayoshi Tonouchi received the B.S. and M.S. and Dr. E. degrees form Osaka University, Japan, in 1983, 1985, and 1988, respectively. From 1988 to 1989 he worked at Osaka University, at Kyushu Institute of Technology, from 1994 to 1996, Communications Research Laboratory, and since then, he was an associate professor of Osaka University. Since 2000, he is a professor of Osaka University. He has published more than 200 research articles in SCI(E) journals, His current research interests include ultrafast optical and terahertz science in advanced materials and development-and-applications of terahertz technology.

Phase-change Materials for Reconfigurable Metaphotonics



Sajjad Abdollahramezani and **Ali Adibi**

School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, USA

Abstract

A new platform for miniaturized reconfigurable nanophotonics and metaphotonics through integration of dielectric, semiconductor, and plasmonic materials with nonvolatile phase-change materials (PCMs) will be discussed. This platform enables reconfigurable photonic building blocks with subwavelength features. Different PCMS for operation in visible and near-infrared wavelengths are discussed, and their role in forming reconfigurable metaphotonic devices with unique features for state-of-the-art applications will be elaborated. Design, fabrication, and application of this platform for state-of-the-art devices and systems will also be covered.

Biography

Ali Adibi is the director of Bio and Environmental Sensing Technologies (BEST) and a professor and Joseph M. Pettit chair in the School of Electrical and Computer Engineering, Georgia Institute of Technology. His research group has pioneered several structures in the field of integrated nanophotonics for both information processing and sensing. He is the author of more than 140 journal papers and 400 conference papers. He is the editor-in-chief of the Journal of Nanophotonics, and the nanophotonic program track chair of the Photonics West meeting. He is the recipient of several awards including Presidential Early Career Award for Scientists and Engineers, Packard Fellowship, NSF CAREER Award, and the SPIE Technology Achievement Award. He is also a fellow of OSA, SPIE, and AAAS.

Giant Control of GHz-THz Nonlinearities in Semiconductor Superlattices

[1,2]Mauro F. Pereira, [2]Apostolos Apostolakis, [3]Vladimir Anfertev and [3]Vladimir Vaks

[1]Department of Physics, Khalifa University of Science and Technology, Abu Dhabi 127788, UAE

[2]Institute of Physics, Czech Academy of Sciences, 18221 Prague, Czech Republic

[3]Institute for Physics of Microstructures, Federal Research Center Institute of Applied Physics of RAS, GSP-105, Nizhny Novgorod, 603950, Russia

Abstract

Optical nonlinearities in semiconductor materials are well understood in the visible and near infrared, but there is still a lot to learn in the Gigahertz-Terahertz (GHz-THz) ranges. In this paper we start by summarizing the results of recently published research where we have demonstrated both theoretically and experimentally real time, low power, room temperature control of GHz-THz nonlinearities in semiconductor superlattices (SSLs), complemented by an analysis of enhancing nonlinearities per structural design. New results will be presented in the talk, including a deeper analysis of combined voltage and design control. The superlattices are used both as nonlinear multipliers and nonlinear mixers for heterodyne detection. If the flow is not perfectly antisymmetric, even harmonics appear even at zero bias. In conventional nonlinear optics, the power emitted by mechanisms described by susceptibilities increase with the input field interacting with nonlinear media. However, in our case, increasing the pump does not lead to maximum output and for high voltages, the maxima develop into "petals", with well-defined maxima and minima, which we have demonstrated experimentally in very good agreement with the theoretical predictions [1-3]. Applications of the superlattices to metabolomics experiments will also be presented.

[1] M.F. Pereira, and A. Apostolakis, Nanomaterials 11, 1287 (2021).

[2] M.F. Pereira et al, Sci Rep 10, 15950 (2020).

[3] A. Apostolakis and M.F. Pereira,Nanophotonics 9, 3941 (2020).

Biography

Prof. Mauro Fernandes Pereira obtained his PhD at the Optical Sciences Center, University of Arizona and specializes in Nonequilibrium Many Body Theories applied to Quantum Transport and Optics in Semiconductors.

He is a Fellow of SPIE, and has been awarded the SPIE Innovation Awards in Quantum Sensing and Nano Electronics and Photonics (2019). He is Professor and Chair of Physics at Khalifa University of Science and Technology and Senior Scientist (on leave) at the Institute of Physics of the Academy of Sciences of Czech Republic.

He is included in Stanford University's List of World's Top 2% of Scientists for 2019.

An operational, real-field, entanglement-based quantum key distribution network

Yoann Pelet, Anthony Martin, Grégory Sauder, Mathis Cohen-Contreres, Laurent Labonté, Olivier Alibart, and **Sébastien Tanzilli**

Université Côte d'Azur, CNRS, Institut de Physique de Nice (INPHYNI), Nice, France

Abstract

The current increase in security requirements of our connected society sets a critical need for practical, absolutely secured, and 24h-a-day operational secret key distribution links. Since the dawn of quantum key distribution (QKD) in 1984 based on single photons, new protocols have been discovered and diversified to meet all the requirements of practical QKD in terms of security, distance, and rate. Today's real-field implementations exploit free-space links toward satellites, terrestrial, and underwater fibre links combined to optimized experimental protocols. For instance, the improved original QKD protocol (decoy BB84) is now used over thousands of km with trusted nodes in China, and can even reach satellites. Twin-field QKD has set the longest distance for a repeaterless link, while entanglement-based protocols (BBM92) can connect several users at a time exploiting frequency multiplexing schemes.

In this context, our real-field network represents the first operational 3-node quantum link in France. It is based on entanglement sharing between two users over 50 km. We have developed a broadband source of entangled photons located at a central node that distributes entanglement to two remote users, located in Sophia-Antipolis (Bob) and Nice city centre (Alice), through a standard metropolitan optical fibre network provided by Orange. We exploit energy-time entanglement for its resilience to optical fibre distribution and its frequency-multiplexing ability. It has required the development of a pair of compact, stable, and identical entanglement analysers, in the form of unbalanced Mach-Zehnder interferometers matching our source and detectors.

The strengths of our implementation are: i) a 3-node clock synchronisation based on quantum signals, ii) a network able to multiplex up to 10 users, and iii) on-the-fly operational secret-key sifting, error correction, and privacy amplification. Our source produces entangled photons at telecom wavelength, at a pair rate of 170×106 per second in 100 GHz channels. We obtain a continuous secure key rate of 7 kbits/s associated with a QBER below 4.5%.

UCA-Jedi, Orange, the ANR, Accenture, and Métropole NCA are warmly acknowledged for their support.

Biography

Sébastien Tanzilli is a CNRS Research Director. He has a 20-year experience in quantum optics and photonics-based quantum technologies, with more than 70 publications in international journals with peer review. His major achievements encompass entanglement-based quantum-communication and quantum-sensor developments. Those include high-precision optical material qualification for laser system applications, as well as telecom-compliant quantum light sources, coherent frequency transducers, and quantum-network synchronization. He has launched or been involved in ~20 research programs as PI or partner, at both the French and European levels. Moreover, he has launched in 2009 and directed for 12 years the CNRS network on quantum engineering.

Polaritonic Nonlinear Metasurfaces for Flat Nonlinear Optics in Mid- and Far-Infrared

Mikhail A. Belkin

Walter Schottky Institute, Technical University of Munich, Garching, Germany

Abstract

Nonlinear optical metasurfaces – planar structures made of a large number of sub-wavelength elements with engineered nonlinear optical response – can enable frequency mixing without phase-matching constrains of bulk nonlinear crystals and manipulation of the shape of the output beam via phase control of the nonlinear response of an individual sub-wavelength element. However, efficient frequency mixing in nonlinear metasurfaces requires nonlinear response orders of magnitude higher than that of traditional materials.

Intersubband transitions in n-doped coupled semiconductor coupled quantum wells allow one to quantum-engineer nonlinear response in semiconductor materials and produce very large optical nonlinearities. This large nonlinear optical response can be further enhanced if intersubband transitions are coupled to electromagnetic modes of optical nanoresonators fabricated in the semiconductor heterostructures to form intersubband nonlinear polaritonic metasurfaces. In this presentation, I will share our results on developing metasurfaces that display second- and third-order nonlinear susceptibility values 4-7 orders of magnitude higher than that of traditional nonlinear materials. In particular, I will present metasurfaces designed for efficient mid-infrared second harmonic and difference-frequency generation with second-order nonlinear susceptibility of ~106 pm/V with controllable phases of the nonlinear optical response and metasurfaces designed for saturable absorption and power limiting.

Biography

Prof. Mikhail Belkin received his PhD degree in Physics from University of California at Berkeley in 2004. In 2004-2008 he did his postdoctoral work in Prof. Federico Capasso group at the Harvard School of Engineering and Applied Sciences. He then joined the faculty of the Department of Electrical and Computer Engineering at The University of Texas at Austin. In 2019, he joined the Department of Electrical Engineering and Walter Schottky Institute of the Technical University of Munich as a Chair of Semiconductor Technology. Prof. Belkin is the Fellow of the OSA and SPIE.

DAY 2 | Session 5

Session Chairs:
Dr. Bernhard Quendt, Dr. Jean-Pierre Huignard

Title: Quantum Information Science and Engineering Programs at the National Science Foundation (NSF)
Dr. Rosa Alejandra Lukaszew, National Science Foundation, USA

Title: Spin-orbit torque switching of metallic antiferromagnets and ferrimagnets
Prof. Pedram Khalili, Northwestern University, USA

Title: Quantum Sensing with Photon Correlations of Classical Light: Ghost Imaging, Ghost Spectroscopy and Ghost Polarimetry
Prof. Wolfgang Elaesser, Technische Universitat Darmstadt, Germany

Title: Graphene-based 2D Heterostructures for Plasmonic Terahertz Laser Transistors and Detectors
Dr. Taichi Otsuji, Tohoku University, Japan

Quantum Information Science and Engineering Programs at the National Science Foundation (NSF)

Rosa Alejandra Lukaszew

Electrical, Communication and Cyber Systems (ECCS), Engineering Directorate (ENG), National Science Foundation (NSF), Alexandria, Virginia, USA

Abstract

The National Science Foundation (NSF) has supported academic fundamental research in quantum information science through its core programs for decades. In more recent years, as the field progressed thanks to ground-breaking demonstrations, and as part of its ten Big Ideas, NSF has added an NSF-wide Quantum Leap program. This program puts a particular emphasis on cross-disciplinary research that includes the exploration of new concepts and platforms, addressing key questions with a convergent team approach in an effort to advance the science from laboratory demonstrations to practical applications. We will present our current activities on research, education and outreach, as well as some recent results obtained under the different projects funded by this effort.

Biography

Dr. Lukaszew, interests encompass classical and quantum communications, sensing, computing, artificial intelligence hardware and next generation computing. Prior joining NSF she served as Program Manager in the Defense Sciences Office at DARPA where she designed programs covering novel classical and quantum devices (e.g. quantum sensing, quantum communication, quantum computing, metrology). She also developed efforts for next generation AI hardware. She is AVS fellow, OSA senior member and Cottrell Scholar. Prior to her administrative career, she was Distinguished Virginia Microelectronics Consortium (VMEC) Professor at the College of William and Mary and currently she is Distinguished Professor Emerita at this institution.

Spin-orbit torque switching of metallic antiferromagnets and ferrimagnets

Pedram Khalili

Department of Electrical and Computer Engineering, Northwestern University, Evanston, Illinois, USA

Abstract

Spin-orbit torque (SOT) control of magnetic order in antiferromagnetic (AFM) and ferrimagnetic (FIM) materials is of great current interest, motivated by their exchange-dominated high-frequency dynamics and small (or absent) macroscopic magnetization, making them excellent candidates for high-speed and robust memory devices.

Here we present our recent results in SOT control of AFM and FIM order. First, we discuss SOT control of AFM order in two metallic antiferromagnets (PtMn and non-collinear IrMn3) [1, 2]. We show that pillars of both AFMs, grown on a heavy metal (HM) layer, can be reversibly switched between different magnetic states by electric currents. We also present an experimental protocol to unambiguously distinguish current-induced magnetic and nonmagnetic switching signals in AFM/HM structures. A six-terminal double-cross device is constructed, with an IrMn3 pillar placed on one cross. The differential voltage is measured between the two crosses after each switching attempt. For a wide range of current densities, reversible switching is observed only when write currents pass through the cross with the IrMn3 pillar. This eliminates the possibility of non-magnetic switching artifacts, which complicated the interpretation of most previous AFM/HM switching experiments.

Next, we present a strategy for deterministic field-free switching of perpendicular ferrimagnetic films by using chiral symmetry-breaking to eliminate the need for an external magnetic field [3]. Bias-field-free SOT switching is demonstrated in a perpendicular CoTb film with an engineered vertical composition gradient. The vertical structural inversion asymmetry induces strong intrinsic SOTs and a gradient-driven Dzyaloshinskii–Moriya interaction (g-DMI), which dynamically breaks the in-plane symmetry during the switching process. This approach is scalable to large wafer size.

[1] Nature Electronics 3, 92, (2020)

[2] Nature Communications 12, 3828, (2021)

[3] Nature Communications 12, 4555, (2021)

Biography

Pedram Khalili Amiri is Associate Professor of Electrical and Computer Engineering at Northwestern University, and Director of the Physical Electronics Research Laboratory (PERL). Previously, he was an Adjunct Assistant Professor (2013-2017) and Research Associate (2009-2013) at UCLA. Pedram received the Ph.D. degree (cum laude) from Delft University of Technology (TU Delft), The Netherlands, in 2008. He was a finalist for the Intermag best student paper award in 2008 and received the Northwestern ECE department's Best Teacher Award in 2020. He serves on the Editorial Board of Journal of Physics: Photonics, and the Early Career Editorial Board of Multifunctional Materials. He has served on technical program committees of numerous conferences, and is a member of the Flash Memory Summit conference advisory board. Pedram represents the IEEE Magnetics Society on the IEEE Task Force for Rebooting Computing (TFRC) Executive Committee. He is a Senior Member of the IEEE.

Quantum Sensing with Photon Correlations of Classical Light: Ghost Imaging, Ghost Spectroscopy and Ghost Polarimetry

Wolfgang Elsaesser

Institute of Applied Physics, Technische Universitaet Darmstadt, 64289 Darmstadt, Germany

Abstract

Ghost metrology is a measurement modality exploiting correlations of photons. In the spirit of the Hanbury-Brown Twiss experiment from 1956, well before the advent of the first laser, we discuss and apply classical photon correlations generated by superluminescent diodes and erbium-doped fiber amplifiers.

On this basis, we realize ghost imaging by using a novel, extremely compact superluminescent diode source based on Amplified Spontaneous Emission and exhibiting photon bunching with a second order correlation coefficient g(2) = 2. Then, we demonstrate that amplified spontaneous emission light emitted both by a spectrally broad-band semiconductor-based superluminescent diode and an erbium-doped fibre amplifier (EDFA) exhibit spectral photon correlations in the spirit of the Hanbury-Brown & Twiss (HBT) experiment, however now in the spectral domain. We apply these spectral photon correlations within two proof-of-principal ghost spectroscopy experiments, one at an absorption band of trichloromethane (chloroform) at 1214 nm and another one at 1533nm at acetylene (C2H2) reproducing the characteristic absorption features. This ghost spectroscopy work fills the gap of a hitherto missing analogy between the spatial and the spectral domain in classical ghost modalities. Finally, by exploiting polarization correlations of light from an EDFA we succeed in reconstructing a hidden, camouflaged polarization in a ghost polarimetry experiment in close analogy to ghost imaging and ghost spectroscopy.

Via these successfully demonstrated results, we are contributing towards a broader dissemination of correlated photon ghost modalities, hence paving the way towards more applications which exploit their favorable advantages.

Biography

Wolfgang Elsäßer received the diploma degree in Physics from the Technical University of Karlsruhe in 1980, the Ph.D. degree in Physics from the University in Stuttgart in 1984, and a Habilitation degree in Experimental Physics from the Philipps-University Marburg in 1991. From 1981 to 1985, he was with the Max-Planck-Institute for Solid State Research Stuttgart. From 1985 to 1995, he was with the Philipps-University Marburg. Since 1995, he is Full Professor in the Institute of Applied Physics, Darmstadt University of Technology, Germany working in the field of Semiconductor Optics. He is a member of the German Physical Society (DPG), Member of the European Physical Society and actually elected member of the council of the EPS and a Senior Member of IEEE. He was awarded with the Otto-Hahn-Medal (1985), the Werner-von-Siemens-Medal (1985), the Rudolf-Kaiser Prize (1991) and the IEE J.J. Thomson Premium (1995). His research interests can be best described by "Photonics and Quantum Optics of Semiconductor Emitters".

Graphene-based 2D Heterostructures for Plasmonic Terahertz Laser Transistors and Detectors

Taiichi Otsuji

Research Institute of Electrical Communication, Tohoku University, Sendai, Miyagi, 9808577 Japan.

Abstract

This paper reviews recent advances in the research of graphene-based 2D heterostructures for plasmonic terahertz laser transistors and detectors. Terahertz (THz) electromagnetic waves are important, but still unexplored frequency range bridging radio and light waves. Compact, high power, and room temperature coherent THz light sources are in high demand to realize the next-generation ultra-high-speed, ultra-broadband 6G and 7G THz wireless communication systems. To make such systems possible, the realization of room-temperature, intense, and ultrafast laser transistors as well as highly sensitive, fast-response detectors operating in a wide sub-terahertz to terahertz range are the mandatory conditions. This paper reviews recent advances in the research of graphene-based 2D heterostructures for plasmonic terahertz laser transistors and detectors. Carrier-injection pumping of graphene can enable negative-dynamic conductivity in the terahertz (THz) range, which may lead to new types of THz lasers. We designed and fabricated the distributed feedback (DFB) dual-grating-gate graphene channel transistors (DGG-GFETs). Broadband rather intense (~80 μW) amplified spontaneous emission from 1 to 7.6 THz and weak (~0.1 μW) single-mode lasing at 5.2 THz were observed at 100K in different samples [1]. Recently we have succeeded in tunable resonant amplification of stimulated emission of THz radiation with the maximal gain of 9% at room temperature in asymmetric DGG-GFET with monolayer graphene as the channel material. The obtained gain was far beyond the well-known landmark level of 2.3% that is the maximum available when photons directly interact with electrons without excitation of graphene plasmons [2]. We also discovered the new instability mechanism of graphene Dirac plasmons (GDPs) called Coulomb-drag instability to interpret the experimentally observed phenomena that could not be quantitatively explained by using any existing theory [3]. In terms of THz detection, nonlinear nature of graphene plasmons enables drastic enhancement of detection responsivity that can well outperform any existing room-temperature fast detectors. Recently we experimentally demonstrated 100-Gbit/s-class fast and sensitive THz detection in an ADGG-GFET utilizing current-driven plasmonic and photothermoelectric rectification mechanisms [4]. Further performance improvements could be addressed by introducing graphene-based van-der-Waals 2D heterostructures serving new physical principles [5]. This work was supported by JSPS KAKENHI #21H04546, and the Commissioned Research by NICT #02301, Japan.

[1] D. Yadav et al., Nanophotonics 7, 741-752 (2018)

[2] S. Boubanga-Tombet et al., Phys. Rev. X 10, 031004 (2020).

[3] V. Ryzhii et al., Phys. Rev. Appl. 16, 014001 (2021); T. Otsuji et al., Nanophotonics 11, 1677-1696 (2022).

[4] K. Tamura et al., APL Photon. 7, 126101 (2022).

[5] V. Ryzhii et al., J. Appl. Phys. 124, 114501 (2018); V. Ryzhii et al., Phys. Rev. B 100, 115436 (2019);

Biography

Taiichi Otsuji received the Ph.D degree in electronic engineering from Tokyo Institute of Technology, Tokyo, Japan in 1994. After working at NTT Laboratories from 1984 to 1999, and Kyushu Institute of Technology from 1999 to 2005, he has been a professor at the Research Institute of Electrical Communication (RIEC), Tohoku University, Sendai, Japan since 2005. He has authored and co-authored 280 peer-reviewed journal papers (h-Index = 49 by SCOPUS). He has served as an IEEE Electron Device Society Distinguished Lecturer since 2013. He is a Fellow of the IEEE, OPTICA, and JSAP.

DAY 2 | Session 6

Session Chairs:
Prof. Gerard Mourou, Prof. Albert Fert, Prof. Manijeh Razeghi

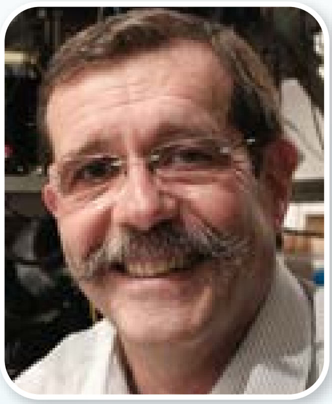
Title: Single Photons, Entangled Photons: From Quantum Foundations to Quantum Technologies

Prof. Alain Aspect Nobel Lecture, Institut d'Optique Graduate School / Université Paris-Saclay / École Polytechnique / Institut Polytechnique de Paris, France

Title: Discussion and future trends

Prof. Leo Esaki, Prof. Albert Fert, Prof. Gerard Mourou and Prof. Manijeh Razeghi

Single Photons, Entangled Photons: From Quantum Foundations to Quantum Technologies



Alain Aspect

Institut d'Optique Graduate School / Université Paris-Saclay
École Polytechnique / Institut Polytechnique de Paris, France

Abstract

Single photons or pairs of entangled photons have been shown to have properties impossible, absolutely impossible, to describe in the framework of the classical model of light. These experimental demonstrations prompted the emergence of revolutionary methods for processing and transmitting information.

Biography

Alain Aspect is an alumnus of Ecole Normale Supérieure de Cachan (now ENS Paris-Saclay) and Université d'Orsay (now Université Paris-Saclay). An emeritus distinguished scientist at CNRS, he is a professor at Institut d'Optique Graduate School where he holds the Augustin Fresnel Chair sponsored by Nokia Bell labs and the Simons foundation. He is also a professor at Ecole Polytechnique, and the author of a textbook and of MOOCS on quantum optics. He is a member of several science academies (France, USA, UK, Austria, Belgium, Italy) and has received many prestigious international prizes.

Aspect research has been devoted to experimental studies of quantum properties of light and ultra-cold atoms, at the root of quantum technologies.

DAY 2 | Session 7

Session Chairs:
Prof. Nader Engheta, Prof. Frederic Grillot

Title: Optical Physics Does Digital Optimization—which we call Onsager Computing for Machine Learning, Control Theory, Backpropagation, etc.
Prof. Eli Yablonovitch, University of California, Berkeley, USA

Title: Programming optical learning machines
Prof. Demetri Psaltis, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

Title: Nonlinear Processing with Only Linear Optics (nPOLO)
Prof. Christophe Moser, Ecole Polytechnique Federale de Lausanne, Switzerland

Title: Diffractive Optical Networks & Computational Imaging Without a Computer
Prof. Aydogan Ozcan, University of California, Los Angeles, USA

Optical Physics Does Digital Optimization –which we call Onsager Computing– for Machine Learning, Control Theory, Backpropagation, etc.

Eli Yablonovitch and Sri Vadlamani

Electrical Engineering and Computer Sciences Dept., University of California, Berkeley, CA, USA

Abstract

Optimization is vital to Engineering, Artificial Intelligence, and to many areas of Science. Mathematically, we usually employ steepest-descent, or other digital algorithms. But, Physics itself, performs optimizations in the normal course of dynamical evolution. Nature provides us with the following optimization principles:

1. The Principle of Least Action;
2. The Variational Principle of Quantum Mechanics;
3. The Principle of Minimum Entropy Generation;
4. The First Mode to Threshold method;
5. The Principle of Least Time;
6. The Adiabatic Evolution method;
7. Quantum Annealing

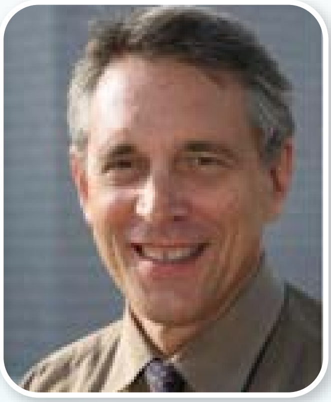
In effect, Physics can provide machines which solve digital optimization problems much faster than any digital computer. Of these physics principles, "Minimum Entropy Generation" in the form of bistable electrical or optical circuits is particularly adaptable toward offering digital Optimization. For example, we provide the electrical circuit which can address the challenging Ising problem, binary magnet energy minimization.

Since Onsager, 1930, introduced the Principle of Minimum Entropy Generation we call this Onsager Computing, as opposed to conventional Von Neumann Computing. Electrical Onsager Computers run ~10000 times faster have ~10000 times less energy-to-solution, than conventional machines. Furthermore, optical Onsager machines provide an addition 1000 times increase in speed.

Biography

Eli Yablonovitch is Director of the NSF Center for Energy Efficient Electronics Science (E3S), a multi-University Center headquartered at Berkeley. Yablonovitch introduced the idea that strained semiconductor lasers could have superior performance due to reduced effective mass (holes). With almost every human interaction with the internet, optical telecommunication occurs by strained semiconductor lasers. He is regarded as a Father of the Photonic BandGap concept, and he coined the term "Photonic Crystal". The geometrical structure of the first experimentally realized Photonic bandgap, is sometimes called "Yablonovite". He was elected to NAE, NAS, NAI, AmAcArSci, and as Foreign Member, UK Royal Society.

Programming optical learning machines



Ilker Oguz, Leo Hsieh, Christophe Moser and **Demetri Psaltis**

Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland

Abstract

The optical implementation of neural networks can be advantageous compared to electronics in terms of power consumption. This derives from the fact that the energy required to transmit information optically can be nearly independent of the distance between the emitter and the receiver. Consequently, optics can be particularly suitable for hardware implementations of neural networks due to the dense connectivity of neural architectures. Neural networks, however, use the strengths of the interconnections between the processing units (the "neurons") as computing and storage elements. An optical neural network must therefore include a mechanism that allows it to be programmed or trained by modifying the strength of the interconnections. In this presentation we will review optical methods and also present recent results for programming optical learning machines implemented with multi-mode fibers.

Biography

Demetri Psaltis is Professor of Optics and the Director of the Optics Laboratory at the Ecole Polytechnique Federale de Lausanne (EPFL). He was a Professor at the California Institute of Technology from 1980 to 2006. He moved to EPFL in 2007. His research interests are imaging, holography, biophotonics, machine learning, nonlinear optics, electrolysis for hydrogen production and optofluidics. Dr.Pslatis is a fellow of the IEEE, the Optical Society of America, the European Optical Society and the Society for Photo-optical Systems Engineering. He received the International Commission of Optics Prize, the Humboldt Award, the Leith Medal, the Gabor Prize and the Joseph Fraunhofer Award/Robert M. Burley Prize.

Nonlinear Processing with Only Linear Optics (nPOLO)

[1]Demetri Psaltis and [2]Christophe Moser

[1]Laboratory of Optics, Institute of Electrical and MicroEngineering,

[2]Laboratory of Applied Photonics Devices, Institute of Electrical and MicroEngineering, Ecole Polytechnique Federale de Lausanne (EPFL) , Lausanne, Switzerland

Abstract

As artificial intelligence (AI) use grows, the demand for computing resources has increased dramatically. For example, a large language model like ChatGPT, requires a large amount of computing power to operate. The server cost alone is $100,000 per day and it performs calculations continuously on 30 thousand graphical processors. These costs are significant and highlight the need for more energy-efficient and cost-effective computing platforms for AI applications and future growth. One potential solution is optical hardware. Optical computing hardware has several advantages, such as high bandwidth parallelism and energy efficiency. However, one major limitation is the implementation of nonlinear calculations in the optical domain. Current solutions for nonlinearity require the use of digital computers in conjunction with linear optical hardware, which is costly and inefficient in terms of energy consumption due to the costly and power-consuming Optical-Electrical-Optical (OEO) conversions that are required many times for large models. This has been the major limitation of the scalability of optical computing hardware. We have shown recently that non-linear optical computations leading to competitive classification tasks can be realized by utilizing the confinement and long interaction length in multimode optical fibers [1,2].

Here, we propose an approach that achieves the equivalent of optical nonlinearity vastly more effectively. The essence of the technique relies on multiple linear scattering that uses low optical power to effectively synthesize a nonlinear operation. By exploiting this relationship, arbitrary nonlinear transformations are programmed digitally, and light effectively performs an all-optical computation without requiring electronic switching or high peak power to achieve non-linearity.

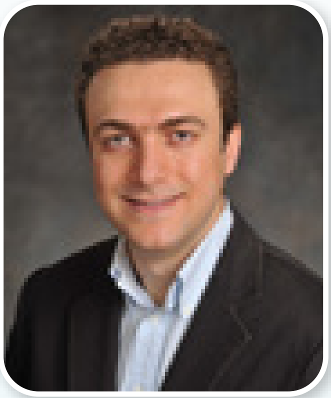
[1] Ugur Tegin, Mustafa Yildirim, Ilker Oguz, Christophe Moser, Demetri Psaltis, Scalable Learning Operator (SOLO), Nature Computational Science, 1, pages542-549 (2021)

[2] Ilker Oguz, Jih-Liang Hsieh , Niyazi Ulas Dinc, Ugur Tegin, Mustafa Yildirim, Carlo Gigli,, Christophe Moser, Demetri Psaltis programming non-linear propagation for efficient optical learning machine, https://arxiv.org/abs/2208.04951

Biography

Christophe Moser is Full Professor of Optics in the department of Electrical and MicroEngineeing (IEM) at EPFL. He obtained his PhD at the California Institute of Technology in optical information processing in 2000. He co-founded and was the CEO of Ondax Inc (now Coherent Inc.), Monrovia California for 10 years before joining EPFL in 2010. His interests are Volumetric 3D printing, optical computing, ultra-compact endoscopy through multimode fibers. He co-founded Composyt light lab in the field of head worn displays in 2014 (acquired by Intel Corporation in 2015). He is the co-founder or EarlySight SA (2019), Readily3D SA (2020) and Modendo (2021). He is the author and co-author of 100 peer reviewed publications and 60 patents.

Diffractive Optical Networks & Computational Imaging Without a Computer



Aydogan Ozcan

[1]Electrical & Computer Engineering, Bioengineering, UCLA, Los Angeles, CA USA.

[2]California NanoSystems Institute, UCLA, Los Angeles, CA USA.

Abstract

I will discuss diffractive optical networks designed by deep learning to all-optically implement various complex functions as the input light diffracts through spatially-engineered surfaces. These diffractive processors designed by deep learning have various applications, e.g., all-optical image analysis, feature detection, object classification, computational imaging and seeing through diffusers, also enabling task-specific camera designs and new optical components for spatial, spectral and temporal beam shaping and spatially-controlled wavelength division multiplexing. These deep learning-designed diffractive systems can broadly impact (1) all-optical statistical inference engines, (2) computational camera and microscope designs and (3) inverse design of optical systems that are task-specific. In this talk, I will give examples of each group, enabling transformative capabilities for various applications of interest in e.g., autonomous systems, defense/security, telecommunications as well as biomedical imaging and sensing.

Biography

Dr. Ozcan is the Chancellor's Professor and the Volgenau Chair for Engineering Innovation at UCLA and an HHMI Professor with the Howard Hughes Medical Institute. He is also the Associate Director of the California NanoSystems Institute. Dr. Ozcan holds >60 issued/granted patents, and is the co-author of >1000 peer-reviewed publications in leading scientific journals/conferences. He is elected Fellow of National Academy of Inventors (NAI), Optica/OSA, AAAS, SPIE, IEEE, AIMBE, RSC, APS and the Guggenheim Foundation, and is a Lifetime Fellow Member of Optica, NAI, AAAS, and SPIE. Dr. Ozcan is also listed as a Highly Cited Researcher by Web of Science.

DAY 2 | Session 8

Session Chairs:
Prof. Selim Shahriar, Prof. Paul-Louis Meunier

Title: Fundamental properties of beam-splitters in classical and quantum optics
Prof. Masud Mansuripur, The University of Arizona, USA

Title: Secured free-space optics with mid-infrared quantum cascade lasers
Prof. Frederic Grillot, Institut Polytechnique de Paris, France

Title: InAs/InAsSb type-II superlattice: Its material properties and applications in IR lasers and photodetectors
Prof. Yong Hang Zhang, Arizona State University, USA

Title: Quantum sensing with ensembles of NV centers in diamond
Dr. Thierry Debuisschert, Thales Research & Technology, France

Title: Quantum sensors with atomic interferometry
Prof. Arnaud Landragin, Sorbonne Université, France

Title: Perfect coupling conditions for MIM antenna in zero magnetic field regions
Dr. Marina Yakovleva, Université Paris-Saclay, France

Title: RIKEN Accelerator-driven compact neutron sources, RANS, and their applications
Dr. Yoshie Otake, RIKEN Center for Advanced Photonics, Japan

Title: Enhancing the Performances of Spintronic Devices using Ion Irradiation
Dr. Dafine Ravelosona, Spin-Ion Technologies, France

Fundamental properties of beam-splitters in classical and quantum optics

Masud Mansuripur and Ewan M. Wright

Fundamental properties of beam-splitters in classical and quantum optics

Abstract

A lossless beam-splitter has certain (complex-valued) probability amplitudes for sending an incoming photon into one of two possible directions. We use elementary laws of classical and quantum optics to obtain general relations among the magnitudes and phases of these probability amplitudes. Proceeding to examine a pair of (nearly) single-mode wavepackets in the number-states $|n_1$ and $|n_2$ that simultaneously arrive at the splitter's input ports, we find the distribution of photon-number states at the output ports using an argument inspired by Feynman's scattering analysis of indistinguishable Bose particles. The result thus obtained coincides with that of the standard quantum-optical treatment of beam-splitters via annihilation and creation operators a ^and a ^t. A simple application of the Feynman method provides a form of justification for the Bose enhancement implicit in the well-known formulas $\hat{a}|n\rangle = \sqrt{n}|n-1\rangle$ and $\hat{a}^\dagger|n\rangle = \sqrt{n+1}|n+1\rangle$.

Biography

Masud Mansuripur (PhD 1981, Stanford University) is Professor and Chair of Optical Data Storage at the College of Optical Sciences, University of Arizona, Tucson. He is the author of "Introduction to Information Theory" (Prentice-Hall, 1987), "The Physical Principles of Magneto-Optical Recording" (Cambridge, 1995), "Classical Optics and its Applications" (Cambridge, 2002, 2nd edition 2009), "Field, Force, Energy and Momentum in Classical Electrodynamics" (Bentham e-books, 2011, 2nd edition, 2017), and "Mathematical Methods in Science and Engineering" (Cognella, 2020). A Fellow of OSA and SPIE, he has published over 280 technical papers in the areas of optical and macromolecular data storage, magneto-optics, optical materials fabrication & characterization, thin film optics, diffraction theory, and problems associated with radiation pressure and photon momentum.

Secured free-space optics with mid-infrared quantum cascade lasers

[1]Frédéric Grillot, [1,2]Olivier Spitz, [2]Gregory Maisons and [2]Mathieu Carras

[1]LTCI, Télécom Paris, Institut Polytechnique de Paris, 19, place Marguerite Perey, 91120 Palaiseau, France

[2]mirSense, Centre d'intégration NanoInnov, 8 avenue de la Vauve, 91120 Palaiseau, France

Abstract

Free Space Optics (FSO) is a growing technology offering higher bandwidth with fast and cost-effective deployment compared to fiber technology. Multiple applications are envisioned such as campus-scaled network, substituting a fiber network after a disaster (e.g., earthquake, floodings, etc.), connecting a drone as a relay in white spot, and private communications. In the latter, the secret message is encoded into a chaotic waveform in such a way that the information is a priori impossible for an eavesdropper to extract. Information security risks are growing considerably due to the unprecedented fast developments in communications and computer technologies, which has attracted a worldwide attention to security enhanced strategies. In this context, mid-infrared quantum cascade lasers are unipolar semiconductor lasers, which have great potential for such applications where privacy is needed. In particular, when the QCL lasing wavelength is between 3 - 5 microns and 8 - 11 microns, the transmission is much better compared to what is obtained with near-infrared wavelengths even though there is fog or haze. On the top of that, a transmission between 8 - 11 microns implies stealth because the room temperature background emits at these wavelengths, which means that it becomes even more difficult to detect a private transmission in this mid-infrared window. In this presentation, we will review about our recent progresses in chaos-based communications with mid infrared quantum cascade lasers, which is of paramount importance for the development of private free-space optical links and their applications to military, government and institutional players and users.

Biography

Frédéric Grillot is a Full Professor at Télécom Paris one of the top French public institutions of higher education and research of engineering in France and a Research Professor at the University of New-Mexico in the United States. His current research interests include, but are not limited to, advanced quantum confined devices using new materials such as quantum dots and dashes, light emitters based on intersubband transitions, nonlinear dynamics and optical chaos in semiconductor lasers systems as well as microwave and silicon photonics applications.

InAs/InAsSb type-II superlattice: Its material properties and applications in IR lasers and photodetectors

Yong-Hang Zhang

Director, Center for Photonics Innovation
Professor, School of Electrical, Computer and Energy Engineering
Arizona State University

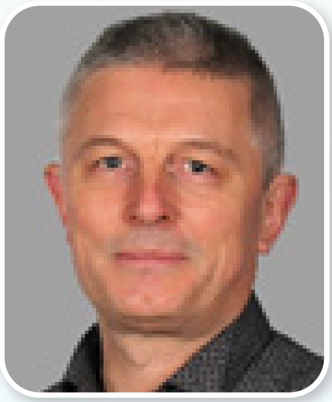
Abstract

This talk will review the research on InAs/InAsSb type-II superlattices (T2SL), especially their growth, structural and electronic properties, and applications to IR lasers and photodetectors with the following highlights: 1) Review of the previous early study of InAs/InAsSb T2SL and its application to IR lasers and photodetectors in the 90's. 2) Long minority carrier lifetime up to 12.8 μs in mid-wavelength infrared (MWIR) InAs/InAsSb T2SL was observed at 15 K, and 412 ns for long-wavelength infrared (LWIR) InAs/InAsSb T2SL were measured using time-resolved photoluminescence. The record long carrier lifetime in the MWIR range is due to carrier localization, which is confirmed by a 3 meV blue shift of the photoluminescence peak energy with increasing temperature from 15 K to 50 K, along with a photoluminescence linewidth broadening up to 40 K. In contrast, no carrier localization is observed in the LWIR T2SL. Modeling results show that carrier localization is stronger in shorter period (9.9 nm) MWIR T2SL as compared to longer period (24.2 nm) LWIR T2SL, indicating that the carrier localization originates mainly from InAs/InAsSb interface disorder. Although carrier localization enhances carrier lifetimes, it also adversely affects carrier transport. 3) Pressure-dependent photoluminescence (PL) experiments under hydrostatic pressures up to 2.16 GPa were conducted on a MWIR InAs/InAsSb T2SL structure at different pump laser excitation powers and sample temperatures. The results show a pressure coefficient of the T2SL transition was found to be 93 ± 2 meV·GPa-1; a clear change in the dominant photo-generated carrier recombination mechanism from radiative to defect related, providing evidence for a defect level situated at 0.18 ± 0.01 eV above the conduction band edge of InAs at ambient pressure. 4) LWIR InAs/InAsSb T2SL nBn photodetectors covering both MWIR and LWIR bands were demonstrated. 5) Hole mobilities are measured using time of flight method.

Biography

He did his research at the Max Planck Institute for Solid States and received his PhD in physics from the University of Stuttgart in 1991. He then worked as an Assistant Research Engineer at UCSB before he joined HRL in 1993. He was appointed Associate Prof. in EE at ASU in 1996 and became a Full Prof. in 2000. He published 4 book chapters, 320 papers, and 20 issued/pending patents, and advised ~70 PhD students, postdocs and visiting scholars. He is a fellow of IEEE and OSA and served as the Associate Dean for Research and the director of NanoFab.

Quantum sensing with ensembles of NV centers in diamond



Thierry Debuisschert, Simone Magaletti, Ludovic Mayer

Thales Research & Technology, 1 avenue Augustin Fresnel, 91767 Palaiseau cedex, France

Abstract

The ability of quantum technologies to control matter on the scale of a single quantum object opens up entirely new possibilities for many applications. Quantum sensing has been identified by Thales as a leading-edge technology with a high potential impact on future navigation, detection and communication systems. We are investigating platforms such as spin impurities in diamond, rare-earth doped crystals, cold atoms, quantum photonics, with a particular focus on practical operational considerations.

Among them, nitrogen-vacancy centers in diamond have very attractive features for various applications. They consist of a nitrogen atom substituted to a carbon atom in the diamond lattice coupled to a vacancy in its immediate vicinity. They behave like an atom in the solid-state with well-defined spin properties and they naturally couple to an external magnetic field. They can be operated at room temperature combining microwave excitation and optical detection of the magnetic resonance. We have used ensembles of NV centers to image the magnetic field distribution of various objects, which has allowed us, first, to characterize the distribution of the current density in an electronic circuit. A following development is based on the use of NV centers implanted in diamond anvil cells for the characterization of phase transitions in materials under high pressure. The versatility of NV centers also makes possible the conversion of a microwave signal into an optical signal. Applying a controlled magnetic field gradient over an ensemble of NV centers, we have demonstrated the real-time spectrum analysis of a microwave field over a broad range covering the whole spectrum of radio-frequency communications. Besides those examples, numerous new applications of NV centers in diamond are expected in the future. Furthermore, this technology can be further extended to new detection techniques or to new defects or host materials.

Biography

Thierry Debuisschert received his PhD from Ecole Normale Supérieure in 1990. He is now a scientific expert at Thales Research & Technology-Fr, where he has been involved in numerous research projects in nonlinear optics, tunable laser sources, quantum communications and quantum sensing. He is the coordinator of the ASTERIQS project which federates the efforts of major European groups on NV-based quantum sensors. As chairman of the Science and Engineering Board he is very involved in the European Quantum Flagship. He has authored more than 50 publications, supervised more than 15 students and served on several scientific boards.

QUEST 2023

Quantum sensors with atomic interferometry

Arnaud Landragin, Quentin Beaufils, Remi Geiger, Carlos Garrido Alzar, Sébastien Merlet, Franck Pereira dos Santos and Leonid Sidorenkov

[1]LNE-SYRTE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, 61 avenue de l'Observatoire, 75014 Paris, France

Abstract

Atomic interferometry is based on the principle of wave-matter duality, stated by Louis de Broglie. In practice, most atomic interferometers are based on the manipulation of atomic wave packets (separation and deflection) by light. Since the pioneering experiments of 1991, atomic interferometry has established itself as a unique tool for the precise measurement of fundamental constants and gravito-inertial effects. It covers multiple applications in metrology, inertial navigation, geophysics, fundamental physics tests, and has been proposed for the detection of gravitational waves. Indeed, atomic interferometry combines both a high intrinsic sensitivity and a high accuracy thanks to the high level of control of the atom-laser interaction. In particular, interferometers with free-falling atoms have shown state-of-the-art performances as gravimeters and gyroscopes, and very promising performances as gradiometers. Important efforts are being made to improve their accuracy and sensitivity by using more coherent atomic sources and more complex atomic manipulation on the one hand, and to make them more robust to parasitic vibrations and to extend their fields of application on the other hand. Behind these developments, trapped or guided interferometers are more prospective and open to new applications such as local force measurements. In particular, they could benefit from quantum engineering protocols to improve the sensitivity below the quantum standard detection limit.

Biography

Arnaud Landragin received the Ph.D. degree in physics from the Université Paris XI, Orsay, France, in 1997. After a two-year postdoctoral fellowship supervised by Pr. Kasevich in Yale University, USA, he obtained the position of researcher in CNRS. He is currently a research director and director of the SYRTE Laboratory. His research interests include the realization and characterization of atom interferometers for application as inertial sensors. He is laureate of the Lamb Price of French Science academy in 2009 and of the CNRS Innovation Medal in 2020. He has published more than 80 research articles in international peer review journals.

Perfect coupling conditions for MIM antenna in zero magnetic field regions

Marina Yakovleva, Fabrice Pardo and Jean-Luc Pelouard

Center for Nanoscience and Nanotechnology, CNRS, Université Paris-Saclay, 91120 Palaiseau, France

Abstract

Due to their unique properties such as sub-wavelength scale field confinement and total absorption at resonance, optical antennas have attracted much interest in studying their properties and using them to improve the performance of various optoelectronic devices. Among these antennas, MIM resonators have been widely studied for various applications as they are easily loaded by a layer of an optically active single crystal. The MIM mode results from a magnetic coupling of the MIM antenna with an incident wave. Thus these antennas are usually located in a high magnetic field region, for example at the mirror surface or at /2 over it. In this talk, we present a study of the MIM behavior when it is located in a null or negligible magnetic field region, for example at /4 over a mirror. This is, for example, the case of a bolometer where the absorbing membrane is replaced by an MIM array. We show that it is possible to obtain full absorption for 1D and 2D arrays of MIM antennas. Under these conditions, we describe in detail the properties of this new type of MIM resonance, its dependence on the antenna geometry as well as the possibility of using this new MIM configuration as a perfect absorber.

Biography

Dr. Yakovleva studied Physics at the Belarusian State University, Belarus, and graduated as MS in 2017. She then joined the research group of Prof. Pelouard at the Center for Nanoscience and Nanotechnology, France, where she worked on a new Lorentz-invariant presentation of the electromagnetic field, and studied the properties of optical nanoantennas. She received her PhD degree in 2021 at the same institution. Since then, she has continued to work with the same group, focusing on the design of MWIR-LWIR photodetectors, based on optical antennas.

RIKEN Accelerator-driven compact neutron sources, RANS, and their applications

Yoshié OTAKE

Neutron Beam Technology Team, RIKEN Center for Advanced Photonics, RIKEN, Japan

Abstract

We have been developing and upgrading Compact Neutron Systems and their applications at RIKEN since 2013[1]. There are two major goals of RANS project. One of the objectives is to construct a floor-standing type of compact neutron systems that enables non-destructive evaluation and analysis of materials and components using low-energy neutrons, which has not been possible until now on-site, and to demonstrate its achievements, thereby contributing to industrial applications and human resource development. Another major objective is to develop and demonstrate outdoors new, transportable, compact neutron systems for preventive maintenance of bridges and other large infrastructure structures, thereby contributing to extending the service life of social capital. Neutron scattering experiments such as imaging, neutron diffraction, and small-angle scattering have been performed on RANS and RANS-II, including for external user applications. As an urgent issue to prevent bridge accidents, we have developed an ultra-compact neutron salt meter, RANS-μ, for salt damage, which is one of the three most common causes of bridge accidents and have already conducted measurements on actual bridges[2]. In addition, we have succeeded in visualizing sedimentation by scattered neutron imaging, which visualizes the internal degradation of bridge decks from the road surface [3]. Efforts toward the practical application of RANS project will also be presented.

Keywords: Compact neutron system, non-destructive test, infrastructure, Quantum beams, Salt meter

Fig.1 RANS challenge, RANS, RANS-II, III, μ

Fig.2 RANS- μ at a bridge

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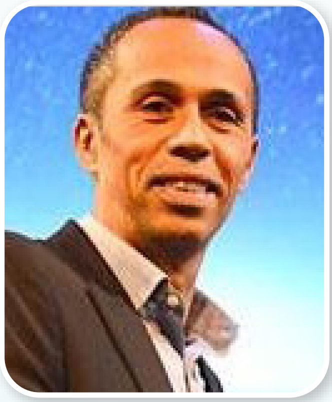
Enhancing the Performances of Spintronic Devices using Ion Irradiation



Dafiné Ravelosona[1,2]

[1]Spin-Ion Technologies, 91120 Palaiseau, France

[2]Centre de Nanosciences et de Nanotechnologies (C2N), CNRS, University of Paris-Saclay, 91120 Palaiseau, France

Abstract

We have developed new manufacturing processes based on ion irradiation to tailor the structural properties of ultra-thin magnetic films and spintronic devices at atomic level and improve their performances. The key feature of the technology is the post-growth control at the atomic scale of structural properties and the corresponding magnetic properties. When realized through a mask this technology allows lateral modulation of magnetic properties without any physical etching. In this talk, we will show a few important results that suggest a pathway to optimize the performances of future generation of spintronic devices using ion irradiation.

DAY 3 | Session 9

Session Chairs:
Prof. Christos Flytzanis, Prof. Jerzy M. Langer

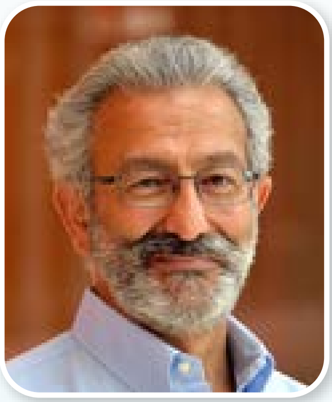
Title: Structuring Light with Metastructures
Prof. Nader Engheta, University of Pennsylvania, USA

Title: Highly stable DFB ridge laser diodes at 852nm and 894nm for Cesium atomic clocks
Dr. Michel Krakowski, III-V Lab, France

Title: Quantum Optics in a Metastable Helium Vapor
Dr. Fabien Bretenaker, LuMin, Université Paris-Saclay, France

Title: Proximitized Quantum Materials: From Superconducting Spintronics to Majorana States
Prof. Igor Zutic, University at Buffalo, USA

Structuring Light with Metastructures



Nader Engheta

University of Pennsylvania School of Engineering and Applied Science Philadelphia, Pennsylvania 19104, USA

Abstract

To manipulate and tailor light we need materials. Judiciously designed metamaterials and metasurfaces can be utilized as tools to structure light and to achieve unconventional light-matter interaction with unprecedented functionalities. The extreme properties of such metastructures provide novel opportunities in optics and photonics. Various paradigms and phenomena enabled by metamaterials include near-zero-index optics, analog computing with waves, 4D optics, optical lumped nanocircuitry, epsilon-near-zero (ENZ)-based quantum and thermal phenomena, and magnet-free nonreciprocity, just to name a few. In this talk, I will give an overview of some of these phenomena and will discuss their salient features resulting from structuring light with metastructures.

Biography

Nader Engheta is the H. Nedwill Ramsey Professor at the University of Pennsylvania. He received his BS degree from the University of Tehran and his MS and PhD degrees from Caltech. His current research activities span a broad range of areas including optics, metamaterials, electrodynamics, microwaves, photonics, nano-optics, and physics and engineering of fields and waves. He has received several awards for his research including the 2023 Benjamin Franklin Medal in Electrical Engineering, the 2020 Isaac Newton Medal and Prize from the Institute of Physics (UK), and the 2020 Max Born Award from the OPTICA (formerly Optical Society. He is a Fellow of IEEE, OPTICA, APS, MRS, SPIE, URSI, AAAS, IOP and NAI. He has received the honorary doctoral degrees from the Aalto University in Finland in 2016, the University of Stuttgart, Germany in 2016, and Ukraine's National Technical University Kharkov Polytechnic Institute in 2017.

Highly stable DFB ridge laser diodes at 852nm and 894nm for Cesium atomic clocks

M.Krakowski, C.Theveneau, A.Larrue, M. Garcia, J.P.Legoec, P.A.Roxo, M.Meghnagi, P. Resneau, Y. Robert, E. Vinet, O. Parillaud, B. Gérard

III-V Lab, 1 av. Augustin Fresnel, 91767, Palaiseau, France

Abstract

We demonstrate Distributed Feedback (DFB) Ridge laser diodes emitting at 852nm and 894nm, at room temperature, and their packaging in hermetic TO-3 can, addressing the pumping of Cesium D2 and D1 lines, respectively. These lasers are key devices for atomic clocks. They respond to all specifications required for the realization of very stable optically pumped compact industrial Cesium beam atomic clocks.

The fabrication requires two epitaxial growth steps carried out in a Low Pressure Metal Organic Vapor Phase Epitaxy (LP-MOVPE) Aixtron multi-wafer reactor on an n-type doped 2 inches GaAs substrate.

The laser active region is Aluminium (Al) free for a better reliability. In addition, the use of Al-free materials makes possible the realisation of a buried Bragg grating (defined by e-beam lithography), for a single frequency operation. This approach allows for a high optical power, a single longitudinal mode operation with a very high rejection of the side modes and a high yield.

These DFB laser diodes show a low threshold current, a high external differential efficiency, with emission in a single spatial mode and in a single frequency, with a very high side mode suppression ratio (SMSR~50dB) and a spectral linewidth below than 1MHz (500kHz< <1MHz). These values of SMSR and linewidth remain stable with the injection current and the operating temperature.

These excellent performances make possible to obtain atomic clocks with very good stability. Allan deviation (ADEV) of 2.7E-12 -1/2 is achieved from 1s to 1000s. ADEVs of 3E-12 and 4E-14 are obtained at 1s and 10 000s, respectively.

The hermetic TO-3 package, designed and assembled with all parts soldered, responds to environmental conditions.

Biography

KRAKOWSKI Michel, graduated in 1980 from the "Ecole Supérieure d'Electricité" and from the University Paris VI (DEA in Materials Science). At III-V Lab he is responsible of the "Pump Lasers" program in the "Optronics Devices" Research Group. He has 40 years of experience in the design, characterisation and reliability study of semiconductor devices, in particular semiconductor lasers, for various applications (high power lasers, telecoms, microwaves, atomic clocks and cold atoms sensors, quantum optics, spectroscopy, metrology, medical). He is author or co-author of more than 100 papers in referred journals and conference proceedings.

Quantum Optics in a Metastable Helium Vapor

Shikang Liu, Pascal Neveu, Louka Hemmen, **Fabien Bretenaker**, and Fabienne Goldfarb

Lumière, Matière et Interfaces (LuMIn), Université Paris-Saclay, ENS Paris-Saclay, CentraleSupélec, CNRS, Gif-sur-Yvette, France

Abstract

We describe our recent investigations of coherent optical processes in a 4He vapor at room temperature. The simple level structure of helium permits to choose very easily the number of levels involved in the probed transition. This permits to isolate new nonlinear processes, leading for example to a high gain phase sensitive amplifier enabled by coherent population trapping. We detail the operation and the characteristics of this process and show that it has recently allowed us to generate a squeezed vacuum. Moreover, we present our recent results concerning spin noise spectroscopy of helium in the vicinity of different transitions.

Biography

Fabien Bretenaker graduated from Ecole Polytechnique, France, in 1988 and received the PhD degree from University of Rennes, France, in 1992 while working on ring laser gyroscopes for Sagem. He joined the Centre National de la Recherche Scientifique in 1994. Presently, Fabien Bretenaker is working in the fields of laser physics, microwave photonics, quantum optics, optical sensors, and quantum technologies. He is the author of more than 200 papers in peer-reviewed journals, 8 patents, and 3 books. He is also the director of LuMIn (Lumière, Matière et Interfaces), a new photonics lab in Paris-Saclay.

Proximitized Quantum Materials: From Superconducting Spintronics to Majorana States

Igor Žutić

University at Buffalo, USA

Abstract

Scaled-down heterostructures and atomically-thin materials suggest a novel approach to systematically design materials as well as to realize exotic states of matter. A given material can be transformed through proximity effects [1] whereby it acquires properties of its neighbors, for example, becoming superconducting, magnetic, topologically nontrivial, or with an enhanced spin-orbit coupling. Such proximity effects not only complement the conventional methods of designing materials, but can also overcome their various limitations. In proximitized materials it is possible to realize properties that are not present in any constituent region of the considered heterostructure. In a simple ferromagnet/superconductor junction with interfacial spin-orbit coupling we discuss our evidence for spin-triplet superconductivity which gives orders of magnitude larger magnetoresistance than in the normal state [2-5]. The resulting spin currents have important implications for superconducting spintronics and low-power emerging applications. A similar proximity-induced spin-triplet superconductivity also supports topologically-protected Majorana bounds states (MBS) for fault-tolerant quantum computing. We discuss our proposal for realizing such MBS in 2D platforms and the challenges for their experimental demonstration [6]. Recent measurements of proximity-induced topological superconductivity [7] provide novel opportunities for controlling MBS and probing their non-Abelian statistics [8].

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Biography

Igor Žutić is a Distinguished Professor of Physics at the University at Buffalo, the State University of New York. He received PhD in theoretical physics at the University of Minnesota in 1998. His work spans topics from spin transport, superconductors, and Majorana fermions, to magnetic nanostructures, proximity effects, and 2D materials. His predictions for spin devices such as spin-photodiodes, transistors, and lasers, have been experimentally realized. With Evgeny Tsymbal, he coedited 3-volume Spintronics Handbook (CRC Press, 2019). Igor Žutić is a Fellow of the American Physical Society.

DAY 3 | Session 10

Session Chairs:
Prof. Hooman Mohseni, Prof. Amr Helmy

Title: Dramatic acceleration and spectral broadening of CdSe /CdS single nanocrystal emission under high excitation or large confinement
Prof. Agnes Maitre, Sorbonne Université, France

Title: Optical Probe of Coherent States in Multi-Functional Materials
Prof. Giti Khodaparast, Virginia Tech, USA

Title: Chiral molecules and the electron spin
Prof. Yossi Paltiel, The Hebrew University, Israel

Title: An in-plane position sensing technique with nm resolution based on machine vision: application to microscopy and laboratory activities
Dr. Olivier Acher, HORIBA France SAS, Palaiseau, France

Title: Quasi-Fermi Level Pinning and Optical Pumping Analysis toward Reduction of Droop in Interband Cascade Lasers
Dr. Linda J. Olafsen, Baylor University, USA

Dramatic acceleration and spectral broadening of Cdse / CdS single nanocrystal emission under high excitation or large confinement

[1,2]Amit Raj Dhawan, [1]Damien Simonot, [1]Agnès Maître

[1]Institut des NanoSciences de Paris, Sorbonne Université, Paris, France.

[2]Department of Materials, University of Oxford, Parks Road, Oxford, OX1 3PH, UK

Abstract

Nanometric semi-conductor colloidal nanocrystals, like CdSe/CdS ones, are excellent single photon sources. Their emission is stable and bright, with a spectral bandwidth of the order of =20-30nm. In specific conditions of high excitation, their emission is dramatically changed. They lose their single photon source quality, the dynamic of the emission is accelerated. the spectrum becomes very large and can reach a few 100nm. Such condition can be achieved either by exciting at high power the emitters or by coupling them to antennas [1], increasing optical confinement.

For emitters at the single or the collective scale, we discuss how the dynamic of emission can illustrate the different recombination process and evidence radiative multiexciton recombination. We develop a model explaining the spectral broadening and illustrating the different recombination processes.

In a second part, we add an optical confinement to the environment of those emitters. We couple these nanoemitters to plasmonic patch nanoantenna, which consists of a thin dielectric medium in which single nanocrystal is embedded and which is sandwiched between a thick gold layer and thin gold patch. We collect antenna emission in far field and measure both intensity and spectrum. We achieve inside plasmonic antennas a high interaction between the emitters and the confined field excited inside the antenna. We evidence a dramatic increase of absorption cross-section of emitters inside these antennas. We demonstrate that the emitters gain specific original quantum properties in such an environment.

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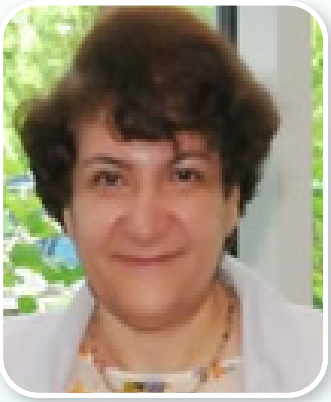
Biography

Pr. Agnès Maître, graduated from Ecole Polytechnique, defended a PhD in "nonlinear optics and atomic physics" in 1994. She joined then Université Denis Diderot, Paris and laboratoire Kastler Brossel in the group of Claude Fabre as an associate professor, working on "quantum nonlinear optics" and "quantum imaging". In 2005, she became professor at Sorbonne Université Paris and joined the Institute of Nanoscience of Paris. She is now working in the fields of plasmonics and single photon sources. She authored more than 70 research papers in peer reviewed journals.

Optical Probe of Coherent States in Multi-Functional Materials



Giti Khodaparast

Department of Physics, Virginia Tech., Blacksburg, VA, 24061, USA.

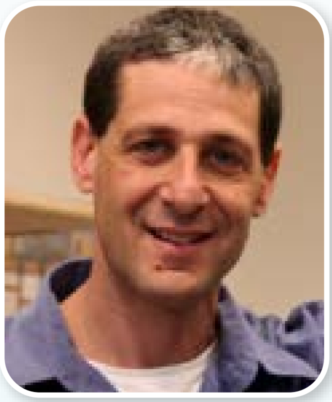
Abstract

Intense laser pulses can generate carriers, spins, phonons, and magnons far from equilibrium states. Information about the dynamical behavior of these nonequilibrium states can be elucidated by: 1) the electronic structure, 2) carrier scattering and relaxation mechanisms, including carrier-phonon and carrier-carrier scattering, 3) spin and magnetization dynamics, and 4) dynamical many-body interactions. For example, coherent acoustic phonons which are ultrasonic strain pulses can result in a broad optical spectrum from GHz up to THz. The possibility of manipulating Coherent Phonons (CP) could lead to develop new techniques such acoustic imaging as well as better understanding and control of electronic and optical properties in devices. Exploring the interaction of CP with carriers, magnetic impurities, and photons can open new prospective of phononics on nanoscale. For example, the manipulation of spins in semiconductors without the application of magnetic fields opens the door to the next generation of devices, where the electronic computation and magnetic memory can be performed on the same chip. In this talk, I will present several time resolved studies including CP generation and control in multi-functional materials such as ferromagnetic materials and mutliferroics.

Biography

Professor Giti Khodaparast research activities at Virginia Tech have been focused to utilize and enhance the importance and power of magneto-optical spectroscopy to explore quantum coherence, correlations, and many-body effects in several materials systems that can play important roles in developing concepts for the next generation of devices or shed lights on the underlying interactions at the nanoscale. She has established modern experimental techniques including femtosecond time resolved optical, magneto-optical, and nonlinear spectroscopy at the physics department. In addition, she has established strong national and international collaborations with large research facilities including the National High Magnetic Field Laboratory in Florida, and the Megagauss Laboratory in Kashiwa, Japan.

Chiral molecules and the electron spin



Yossi Paltiel

Department of Applied Physics, Center for nano science and nano technology, The Hebrew University, Jerusalem, Israel

Abstract

Chirality plays a major role in Biology, Physics, and Chemistry. Life on earth is based on chiral molecules having a specific symmetry - such as in DNA, sugars, and proteins. Bitter experience showed that chiral drugs having the same chemical composition but opposite chirality may have extremely different biological effects.

We are trying to obtain a convincing mechanism that explains why chirality prevailed through evolution remains a major challenge in the biological sciences - and rising to this challenge may require input from disciplines beyond biology to physics and chemistry. Fortuitously, roughly ten years ago it was discovered that electron transfer through chiral molecules depends on the direction of the electron spin, a quantum mechanical property associated with the electron's magnetic moment [1,2]. This observation, termed chiral induced spin selectivity (CISS), may provide new reasoning for explaining]/why enantiomeric purity dominates biological material [3,4].

Studies demonstrated that chiral molecules can serve as very efficient spin filters or polarizers, achieving in some cases spin selectivity of over 80% [5]. This opens the way to construct simple, local, and efficient interface spintronics devices [6,7]. CISS based memory devices can be scaled down to the nano-metric scale [8,9]. Moreover, we showed that when chiral molecules are adsorbed on the surface of thin ferromagnetic film, they induce magnetization perpendicular to the surface, without the application of current or external magnetic field [10].

The opposite effect led to the demonstration an enantioselective interaction of chiral molecules with a substrate magnetized perpendicular to its surface. The discrimination is resulting from the CISS effect and is mediated by a spin-specific interaction but not by the magnetic field per se [11]. As a corollary, charge redistribution in chiral molecules is also accompanied by enantio-specific spin polarization, thus chiral molecules will interact by spin exchange with perpendicularly magnetized surfaces. The interaction should be spin sensitive by virtue of short-spin exchange interactions [12]. These promising studies were followed by additional studies on enantio-specific processes such as crystallization [13] and spin selective chemistry [14,15].

Biography

Professor Yossi Paltiel have in-depth experience in both basic and applied science in the fields of current transport, spin transport, optics, quantum biology, and device fabrication and characterization. He is a world leader in the study of the CISS effect, and my lab research, which included the development of unique measurement techniques, has led to several breakthroughs in the study of the CISS effect. Since 2009, Prof. Paltiel have led the Quantum Nano Engineering group, combining physics, biology, and chemistry. I expect to succeed in leading the CISS research, as I have successfully led research in major high-tech industry and in the academic world.

An in-plane position sensing technique with nm resolution based on machine vision: application to microscopy and laboratory activities

Olivier Acher

HORIBA France SAS, Palaiseau, France

Abstract

We present a technology for position sensing that provides in-plane position and orientation with a spatial resolution as low as 1nm [1], and an angular resolution better than 10 µrad [2]. Position is determined by imaging a scale with proprietary patterns, using a microscope or any other vision system with a digital camera, and treating the image through a software that we developed.

With the development of micro- and nanotechnologies, the capability to obtain reproducible, precise and stable positioning is of increasing importance, at the µm or sub-µm level. With our technology, the in-plane positioning stability, reproducibility and accuracy can be controlled at the desired level, in a much simpler manner than by using an interferometer. Stability results are shown for several microscopes, along with reproducibility and accuracy results on optical and scanning electron microscope stages.

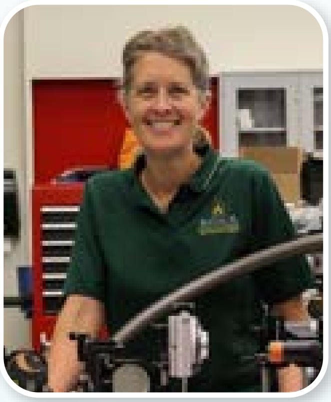
Performing observations on the same points of interest with different microscopes (termed "correlative microscopy") is also of increasing importance. We developed small (few mm²) nanoGPS tags that can be attached to samples, and serve as position & orientation markers [3]. The determination of coordinate transfer parameters between sample and instrument referential can be obtained from a single picture of the tag. Examples of correlative observations between optical and scanning electron microscopes, obtained with this method, are given.

1. O. Acher, and T.-L. Nguyen, Turning a machine vision camera into a high precision position and angle encoder: nanoGPS-OxyO (SPIE, 2019).
2. M. Pisani, M. Astrua, P.-A. Carles, S. Kubsky, T.-L. Nguyên, and O. Acher, "Characterization of Angle Accuracy and Precision of 3-Degree-of-Freedom Absolute Encoder Based on NanoGPS OxyO Technology," Sensors 20, 3462 (2020).
3. O. Acher, T.-L. Nguyên, A. Podzorov, M. Leroy, P.-A. Carles, and S. Legendre, "An efficient solution for correlative microscopy and co-localized observations based on multiscale multimodal machine-readable nanoGPS tags," Measurement Science and Technology 32, 045402 (2021).

Biography

Dr Olivier Acher graduated from the Ecole Polytechnique and performed his PhD at Thomson-CSF Central Research Laboratory, under the supervision of Manijeh Razeghi. In 1990 he joined CEA and carried Applied Research in the field of microwave magnetic materials; he created the Microwave Magnetism Laboratory in Tours, and became Directeur de Recherche in 2002. In 2009, he joined the company HORIBA-Jobin-Yvon as Director of Innovation. He published more than 100 papers and co-authored more than 35 patents.

Quasi-Fermi Level Pinning and Optical Pumping Analysis toward Reduction of Droop in Interband Cascade Lasers



Linda J. Olafsen

Department of Electrical and Computer Engineering, Baylor University, Waco, TX, USA

Abstract

Interband cascade lasers, which employ repeated stages to yield multiple photons per injected electron as compared with a single photon per injected electron in conventional quantum well lasers, provide a promising source for efficient emission and operation at wavelengths of 3–6 μm. This range coincides with an atmospheric transmission window that is eye safe and in which chemical sensitivities are 100–10,000 times better than at shorter wavelengths.

Significant advances have been achieved in interband cascade laser performance utilizing wave function engineering and carrier rebalancing, increasing optimism and opportunity for these devices to act as efficient mid-infrared. However, declining efficiency with increasing current (droop) at high temperatures as yet limits the power output of these lasers relative to the ideal theoretical limit. Evidence of carrier concentration and quasi-Fermi level pinning at low temperatures and non-pinning at high temperatures will be presented and correlated with ICL output for electrical injection as well as for optical pumping. Optical pumping recently has been employed to demonstrate lasing in interband cascade lasers, and the application of this excitation technique to generate sufficient photovoltage for lasing will be discussed, with a view toward isolating efficiency limiting mechanisms and subsequently improving future laser designs. Integration of graphene layers that have high electrical, optical, and thermal conductivity on indium arsenide or gallium antimonide semiconductor surfaces as a transparent top contact also will be presented, including effects on spectral emission. A long-term goal includes application of these transparent contact layers to further enhance efficiency, as well as to provide a deeper understanding of the integration of 2D and 3D materials.

Biography

Linda Olafsen earned an A.B. at Princeton University and Master's and Ph.D. degrees at Duke University in Physics. Dr. Olafsen was a National Research Council postdoctoral research associate at Naval Research Laboratory in Washington, D.C. before joining the faculty at the University of Kansas, receiving an Office of Naval Research Young Investigator Award. She currently is an Associate Professor of Electrical and Computer Engineering at Baylor University. Her research is focused on the development of efficient mid-infrared semiconductor lasers at or above room temperature, as well as the application of materials and infrared sensing to biomedical devices and systems.

DAY 3 | Session 11

Session Chairs:
Prof. Hiroshi Ito, Prof. Eli Yablonovitch

Title: Inertial Navigation with cold atom on chip
Dr. Matthieu Dupont-Nivet, Thales Research and Technology, France

Title: Purcell Effect in Plasmonic and Dielectric Resonators
Dr. Sebastien Bidault, Institut Langevin, ESPCI Paris, Université PSL, CNRS, Paris, France

Title: Probing the infrared thermal radiation of patch antennas
Dr. Yannick de Wilde, ESPCI Paris, PSL University, CNRS, Institut Langevin, France

Title: Spin-Lasers: With Ultrafast Polarization Modulation to the Next Generation of Optical Communication Systems
Dr. Nils C. Gerhardt, Ruhr-University Bochum, Germany

Title: An Engineering Theory of Sensing
Dr. Paolo Rocchi, IBM and LUISS University, Italy

Inertial Navigation with cold atom on chip

[1,2]B. Wirtschafter, [3]L. Boutin, [3]L. Fulop, [1]A. Brignon, [1]D. Dolfi, [2]C. I. Westbrook, [1]**M. Dupont-Nivet**

[1]Thales Resaerch and Technology France, 1 av. Fresnel, 91767 Palaiseau, France

[2]Université Paris-Saclay, Institut d'Optique Graduate School, CNRS, Laboratoire Charles Fabry 91127 Palaiseau, France

[3]iXblue – systèmes photoniques, 11, av. De Canterane, 33600, Pessac

Abstract

Inertial Measurement Units (IMU) including a clock, three-axes accelerometers and gyrometers, are a widely used navigation solution where the position error is proportional to the acceleration and rotation measurement errors and increases with the navigation time. Cold atoms are a good candidate technology for the improvement of the sensibility and stability of these inertial sensors. The size of this technology still need to be decreased to fit in the few liters volume allocated to IMU. To this purpose, enabling technologies used to implement the sensor head, such as atom chip, and the optical cooling system, such as micro-optical assembly, will be presented.

Atom chip allows realizing compact devices and sensing inertial effect. In this approach, we use a Ramsey interferometer scheme and two dressed traps (for two 87 Rubidium states) are created with two microwave potentials (with two microwave frequencies on two coplanar waveguides) and a direct current (DC) magnetic potential. This will result in two independently adjustable internal-state-labelled potentials one for each of the two interferometer states. Turning on and off the two microwave fields will split the atoms along a line and detects acceleration. For rotation, the two state trajectories enclosed an area by moving the DC magnetic potential and turning on and off the two microwave potentials. Clock will be done by letting the dressing microwave fields off.

The presentation will emphasis on the following experimental and theoretical developments: interferometer contrast as a function of the two trapping potential symmetry, the effect of the interaction in a non-condensate ultra-cold gas on the interferometer parameters, and a first demonstration of Ramsey fringes with spatial splitting of the two interferometer states.

Biography

Dr. Matthieu Dupont-Nivet graduated from Institut d'Optique Graduate School (SupOptique) and Ecole Supérieure de Physique et Chimie Industrielle (ESPCI), France, in 2012. He received his Ph.D. degree from the University of Paris-Saclay, in 2016, with a thesis on cold atoms trapped with an atom chip for inertial sensing. Since 2016, he is a research scientist in Thales Research and Technology, Palaiseau, France, where he works on inertial sensing with cold atoms trapped on atom chip. He also works on stimulated Raman adiabatic passage and spin interaction dynamic in cold atom Ramsey interferometers. He authored and co-authored 8 papers, 7 patents.

Purcell Effect in Plasmonic and Dielectric Resonators

Sébastien Bidault

Institut Langevin, ESPCI Paris, Université PSL, CNRS, Paris, France

Abstract

Light-matter interactions in condensed media at room-temperature are fundamentally limited by electron-phonon coupling. For instance, while the excitation cross-section of an isolated atom, or of a single quantum emitter at cryogenic temperatures, can reach one half of the wavelength of light squared (meaning that ~50% of incoming photons will interact for a diffraction-limited excitation); this value is reduced by 6-7 orders of magnitude for a fluorescent molecule or for a colloidal quantum dot at room temperature because of homogeneous phonon broadening. In order to render the exceptional optical properties of single quantum systems (such as single-photon emission and nonlinearities) efficiently accessible at room temperature and in condensed media, it is essential to enhance and optimize these interaction cross-sections.

In this presentation, I will detail some of our recent work towards this goal. In particular, I will describe how DNA-based self-assembly can be used to introduce, in a deterministic way, a controlled number of quantum emitters in the nanoscale hot-spot of a plasmonic resonator. Using this approach, we can enhance single-photon emission from fluorescent molecules by more than two orders of magnitude in a weak-coupling regime. Using five organic molecules, it is also possible to reach a strong-coupling regime with a single dimer of gold nanoparticles.

An alternative platform to plasmonics, in order to enhance light-matter interactions at room temperature, is the use of nanoscale optical resonators made of high-index dielectric materials such as silicon or gallium phosphide. I will discuss some of our recent work on the use of silicon resonators to enhance or inhibit spontaneous emission from electric or magnetic optical emitters; as well as the development of colloidal dielectric resonators to enhance quadratic or cubic nonlinear optical properties.

Biography

Sébastien Bidault is a CNRS Researcher at Institut Langevin in Paris since 2008. He defended a PhD thesis in nonlinear optics in 2004 under the supervision of Sophie Brasselet and Joseph Zyss at ENS Cachan, before joining the group of Albert Polman at the AMOLF Institute in Amsterdam for a post-doctoral project in Plasmonics. His group develops novel nanofabrication techniques based on colloidal chemistry and DNA nanotechnology with applications in optical biosensing; studies the Purcell effect in plasmonic and dielectric nanoantennas; and exploits far-field wavefront shaping in disordered nanophotonic media.

Probing the infrared thermal radiation of patch antennas

[1,2]Loubnan Abou HAMDAN, [1]Valentina KRACHMALNICOFF, [2]Patrick BOUCHON, [2]Riad HAIDAR, [1]**Yannick DE WILDE**

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[2]DOTA, ONERA, Université Paris-Saclay, F-91123 Palaiseau, France

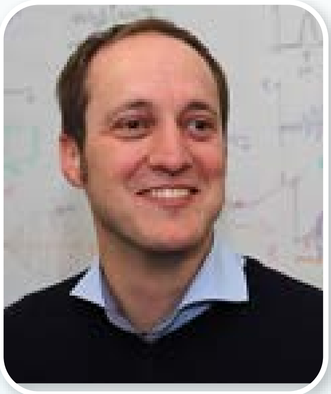
Abstract

To probe the intrinsic electromagnetic response of single patch antennas, we have developed an infrared spatial modulation spectroscopy (IR-SMS) technique which allows to detect extremely small thermal radiation signals without background [C. Li et al., Phys. Rev. Lett. 47, 243901 (2018); H. Kallel et al., JQSRT 236, 106598 (2019)]. We have applied it in combination with thermal radiation scanning tunnelling microscopy [Y. De Wilde et al., Nature 444, 740 (2006)] to measure both near-field images of the thermally excited electromagnetic modes on a patch antenna and the corresponding far-field thermal radiation spectra. When the dielectric spacer material of the patch is silica, different spectral resonances are associated with the same distribution of the electromagnetic field. This unexpected result finds its origin in the resonant behaviour of the optical index of silica in the mid-infrared. On a dimer of patch antennas, the spectral signature of hybrid modes resulting from near-field coupling is observed [L. Abou-Hamdan et al., Opt. Lett. 46, 981 (2021)].

Biography

Dr. Yannick DE WILDE is research director employed by the CNRS and the Deputy Director of the Institut Langevin at ESPCI Paris, PSL University, where he coordinates the activities on Subwavelength Physics. He is an experimental physicist and his main research interests are on nano-optics and plasmonics, thermal radiation at small scales, and scanning near-field microscopies. Among others, he is the inventor of the thermal radiation scanning tunneling microscope (TRSTM) which allows to measure the infrared thermal radiation in the near-field with nanometer resolution, and of other advanced imaging and spectroscopy techniques.

Spin-Lasers: With Ultrafast Polarization Modulation to the Next Generation of Optical Communication Systems



[1]N. Jung, [1]M. Lindemann, [2]T. Pusch, [2]R. Michalzik, [1]M.R. Hofmann and [1]**N.C. Gerhardt**

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[2]Institute of Functional Nanosystems, Ulm University, 89081 Ulm, Germany

Abstract

In times of big data, Internet of things and cloud computing, high-transmission bandwidth with improved energy efficiency provided by optical communications systems is crucial and a key enabler for global digitalization. A critical bottleneck for today's optical communication systems is the modulation frequency of the optical links. It is questionable if future bandwidth requirements can be met by conventional laser technology while reducing power consumption. Spin-lasers, in particular spin-polarized vertical-cavity surface-emitting lasers (spin-VCSELs), that exploit the coupling between carrier spin and photon spin, have recently demonstrated to be a highly promising new device technology to overcome this bottleneck. The dynamics of the coupled spin system in spin-lasers is typically decoupled from the intensity dynamics in conventional, current modulated semiconductor lasers and can reach frequencies > 200 GHz. These large frequencies can be obtained by increasing the resonance frequency of the spin system using strong birefringence coupling of the polarized laser modes in the cavity. Modulating the polarization in these birefringent spin-lasers via the carrier spin potentially enables data rates approaching 1 Tbit/s. Furthermore, the ultrafast polarization dynamics can be obtained for low pumping levels close to threshold and are less sensitive to temperature increase than conventional intensity dynamics. Overall, this makes spin-VCSELs perfect candidates for the next generation of ultrafast optical communication systems with low power consumption.

Here we present the recent developments on ultrafast spin-lasers and discuss novel routes to combine the idea of ultrafast polarization modulation with different integrated device concepts for future communication applications as well as for many other emerging applications such as radio-over-fiber, neuromorphic computing, or THz generation.

Biography

Dr.-Ing. Nils C. Gerhardt studied physics at the Philipps-University Marburg and received his diploma in 2001. 2002 he joined the Ruhr-University Bochum where he finished his Ph.D. in 2005 in electrical engineering in the group of Prof. M. Hofmann. During his time as a postgraduate student he joined the Optoelectronic Research Centre in Tampere, Finland as a Marie-Curie fellow. 2006 he co-founded the PhotonIQ Technologies GmbH. Since 2021 he is Extraordinary Professor in Bochum. He is author or co-author of more than 150 international publications. His research interests include semiconductor spintronics, ultrafast lasers for optical communication and optical imaging.

An Engineering Theory of Sensing

[1,2]Paolo Rocchi

[1]IBM, via Luigi Stipa 150;Roma, Italy.

[2]LUISS University, via Romania 32, Roma, Italy

Abstract

Engineers and technicians calculate sensors using an assortment of empirical formulas, they take advantage of the Fourier series and the Bayesian methods, the infinitesimal calculus and combinatorics etc. This fractioned intellectual landscape lessens the effectiveness of experts, and the literature offers various theories which aim at reunifying and rationalizing the measurement criteria. Some frames pursue technical scopes – e. g. the detection theory – which although are narrow; others cover broader areas – e. g. the constructivist theory of perception – however they deal with foreign topics such as psychology, physiology etc. An engineering theory has nothing to do with philosophy, it must enhance the scientific knowledge, it must unify the mathematical tools ordinarily in use and suggest effective professional guidelines. A work of this kind starts with a few definitions and axioms and infers all the mathematical results through deductive reasoning. We put forward a novel construction in order to pursue these objectives.

The proposed comprehensive frame begins with the piece of information Z that is a word, a signal, a bit, a photo, a sound etc. Professional experience and semiotics teach us that Z includes two elements, the physical body X called signifier or form, and its meaning or signified Y

$$Z = \{X, Y\}. \qquad (1)$$

Perception establishes the birth of information and we formulate this criterion. Whatever body X can be perceived if and only if it differs from the adjacent element X* respect to the observer or probe K

$$X \neq_K X^*. \qquad (2)$$

The informational state of Z depends on the references X* and K namely it is a relativistic notion and should not be understood as an absolute. The second definition explains how X stands for Y, formally X executes a semantic function

$$X \quad Y. \qquad (3)$$

Eqn. (1) is a general law while X can take different shapes (X is also a generic material object). From (1) we can infer the parameters measuring the perceptual quality of X such as intensity, statistical spread, fuzziness, luminance contrast, bandwidth gain and so forth. The abundance of signifiers respect to the signified Y leads to the redundancy R from which one can deduce the redundancy factor, the Shannon redundancy, the replication factor etc. as special cases. Moreover, R establishes a direct link with reliability that is to say R enables the uniform calculus of circuits and data, devices and information. Eqn. (2) and (3) yield the optimal criteria to design (elementary) Z which can be digital or analog signals. Last but not least, the present sensing theory is a part of a broader frame about information and computing.

Rocchi P. (2007), How 'Unused' Codewords Make a Redundant Code, Proc. 45th ACM Southeast Conference, pp. 407-412.

Rocchi P. (2013), Logic of Analog and Digital Machines, Nova Science Publishers, N.Y.

Rocchi P. (2016), What information to measure? How to measure it?, Kybernetes, 45(5), pp.718-731.

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Biography

Paolo Rocchi received his degree in physics from the University La Sapienza of Rome in 1969. Next year he joined IBM where he worked as researcher and teacher for nearly forty years. Upon retirement in 2010 has been recognized as an Emeritus Docent of IBM. Presently he is also an Adjunct Professor at Luiss University of Rome.

Rocchi investigated applied and theoretical topics including computer security, information theory, software methodology, artificial intelligence and education. Rocchi also produced results in probability theory and quantum mechanics. He has introduced a new form of entropy to calculate the reliability and reparability of systems. Rocchi has written over one hundred and forty works including a dozen books.

DAY 3 | Session 12

Session Chairs:
Dr. Binh-Minh Nguyen, Dr. Yannick de Wilde

Title: Purcell Effect versus Auger Scattering in Resonant Mid-Infrared W-Superlattice LEDs
Prof. John Prineas, University of Iowa, USA

Title: Hyperbolic Phonon Polaritons as a Route for Nanophotonic Devices
Prof. Joseph Tischler, University of Oklahoma, USA

Title: Nonlinear THz absorption in graphene plasmons
Prof. Jeong Woo Han, Universität Duisburg-Essen, Germany

Title: Ferroelectric nitride semiconductors: Epitaxy, Quantum engineering, and emerging applications
Prof. Mi Zetian, University of Michigan, USA

Title: Generation and manipulation of frequency states of light with AlGaAs quantum sources
Prof. Maria Ines Amanti, Université Paris Diderot, France

Title: Low-Noise Terahertz-Wave Detector: Fermi-Level Managed Barrier Diode
Prof. Hiroshi Ito, The University of Tokyo, Japan

Title: Recent Progress in Long Wavelength Interband Cascade Lasers
Prof. Rui Q. Yang, University of Oklahoma, USA

Title: Ultrafast plasmon-enhanced deterministically assembled single-photon sources based on nanodiamond color centers
Dr. Simeon I. Bogdanov, University of Illinois Urbana-Champaign, USA

Purcell Effect Versus Auger Scattering in Resonant Mid-Infrared W-Superlattice LEDs

John Prineas

Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA

Abstract

Mid infrared LEDs have growing importance in optical chemical sensing of gases and molecules and are aspirational in LED arrays for projection and illumination due to their high modulation bandwidth, compact form factor, ignition-free operation, advancing radiance and wallplug efficiency, and low cost. Whereas early efforts focused on using single stage alloys, such InAs, InAsSb, and InAsSbP, more recent efforts have focused on cascaded broken gap superlattices such as InAs/GaSb and W-superlattices as well as W-quantum wells due to superior suppression of nonradiative Auger scattering and high internal quantum efficiency. Due to the very high index of refraction compared to nitrides and arsenides, total internal reflection is high making light extraction particularly problematic. Backside roughening has had limited success. One effort to enhance extraction efficiency as well as internal quantum efficiency is via the Purcell effect in resonant structures. However, positioning emission regions at antinodes requires them to be thin, increasing carrier density and Auger scattering, which scales as the square of carrier density. Here, we present ultrafast optical measurements of the ABC coefficients (Shockley-Read-Hall, radiative, and Auger coefficients in W-superlattices, respectively, at low and room temperature) that breaks down their high internal quantum efficiency, and explore the efficiency trade space of Purcell effect and Auger in thin versus thick resonant W-superlattice mid-infrared LEDs in theory and experiment. Results show resonant mid-infrared LEDs that use superlattices of intermediate thickness outperform W-quantum wells across all current densities.

Biography

John P. Prineas earned his B.A. in Physics from Carleton College, MN, USA and his Ph.D. in Physics from The University of Arizona, AZ, USA where he studied light-matter coupling in semiconductor heterostructures with Hyatt Gibbs at the College of Optics, and with Jaghdeep Shah at Lucent Technologies. After doing research at the Max Planck Institute for Solid State Research in Stuttgart, Germany with Juergan Kuhl as an Alexander von Humbolt Fellow, he joined the faculty at The University of Iowa, IA, USA in 2001. He is currently a Professor in The Department of Physics and Astronomy.

Hyperbolic Phonon Polaritons as a Route for Nanophotonic Devices

[1]Eric Seabron, [1]Eric Jackson, [1]Chase Ellis and [1,2,3]Joseph Tischler

[1]Electronics Science and Technology Division, U.S. Naval Research Laboratory, Washington, DC, USA.

[2]Department Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA.

[3]Center for Quantum Research and Technology, University of Oklahoma, Norman, Oklahoma, USA.

Abstract

Phonon Polaritons are attracting considerable interest due to their ability to confine light in small volumes and their resulting potential for applications in photonics. Anisotropic optical materials such as 2D materials and molecular crystals enable the excitation of hyperbolic phonon polaritons. In this case, the real part of the dielectric constant (Re[ ]) has opposite signs along different crystal axes - constraining the propagation of light to specific paths. These materials become particularly interesting if the Re[ ] in one of the in-plane-axis is negative while in the other in-plane-axis is positive. Such materials exhibit highly-reflective, metallic-like properties in one of the in-plane directions (negative Re[ ]) and dielectric-like properties in the other in-plane direction (positive Re[ ]). Also, materials having one axis with metallic-like behavior and two axes with dielectric-like properties are called Type I, and those with two metallic-like and one dielectric-like axis are called Type II. The combination of in-plane-hyperbolicity and surface nanostructuring opens the door to novel nanophotonic applications ranging from on-chip spectrometers with no moving parts, topological photonics for chemical sensing, and interconnected nanophotonic logic. In this talk we will present numerical modeling and experimental demonstration of hyperbolic phonon polaritons in which the material anisotropy and nanostructure anisotropy is independently varied. We demonstrated the occurrence of both surface and volume phonon polaritons in the Type I and Type II bands of hyperbolic materials.

Biography

Dr. Joseph Tischler obtained his Licenciatura from the University of Buenos Aires and his PhD from The University at Buffalo. He joined the U.S. Naval Research Laboratory as a National Research Council Postdoctoral Fellow in 2000. In 2002 he was hired as a Research Physicist eventually becoming the Head of the Nano-Optoelectronics Section and subsequently of the Optoelectronics and Radiation Effects Branch. In 2021 Dr. Tischler joined the University of Oklahoma as an Associate Professor and Avenir Foundation Chair in Condensed Matter Physics. He has published more than 100 research articles in scientific journals and holds several patents.

Nonlinear THz absorption in graphene plasmons

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Abstract

Graphene is a very versatile material for optoelectronics or nonlinear optics in a large spectral range, in particular for THz radiation. One drawback is the low interaction volume between THz radiation and the single atomic layer, which limits the light matter interaction at elevated photon frequencies. During the recent years it has been shown that patterning graphene into plasmonic structures, e.g. ribbons or disks, can shift the rather strong optical response of free charge carriers at low frequencies to a more confined plasmonic resonance at higher frequencies. The size of the structure, in combination with the carrier density, determines the plasmon frequency, which can be tailored toward THz frequency range. This makes patterned graphene a versatile platform applicable in optoelectronic devices operating at THz frequencies. Beyond the linear absorption, the nonlinear optical properties are enhanced by about two orders of magnitude under resonance compared to unpatterned graphene. Here we present a set of studies that quantify the thermal effect when the structures are excited with strong THz laser pulses: the charge carriers are heated efficiently, as their specific heat is rather low. As the temperature increases, the chemical potential and therewith the plasmon frequency is decreased. Compared to thermal nonlinearities in conventional materials, thermal nonlinearities in graphene are very fast as the hot charge carriers cool down within several tens of picoseconds. Polarization-resolved pump-probe measurements on graphene disks revealed nonlinear absorption beyond thermal effects, i.e. plasmonic nonlinearities: thermal and nonthermal effect can be distinguished by using cross- and co-polarized pump-probe measurements. Numerical simulations, considering thermal as well as plasmonic nonlinearities, match the observed signals well, giving a complete picture of the nonlinear processes in graphene plasmons. Additionally, we introduce recently obtained experimental evidence regarding pump-induced Faraday rotation F in graphene disks: a circularly polarized pump pulse leads to circular plasmons that are related to circulating charge carriers and hence results in magnetic fields. This quasi-static magnetic field causes Faraday rotation for linearly polarized probe radiation.

Biography

Dr. Han received his BS in Physics from Kookmin University (South Korea) in 2012. For his MS and PhD, he investigated the electronic structure and carrier dynamics for strongly correlated systems at Gwangju Institute of Science and Technology (South Korea). He received his MS and PhD in 2014 and 2019, respectively. Subsequently, he moved to the University of Duisburg-Essen (Germany) and is investigating the research fields of carrier dynamics in various materials using static- and time-resolved spectroscopic tools in the terahertz frequency range as a postdoctoral researcher.

Ferroelectric nitride semiconductors: Epitaxy, quantum engineering, and emerging applications

Zetian Mi

Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI, USA

Abstract

The incorporation of IIIB and rare-earth elements, such as scandium (Sc), can transform, conventional III-nitride semiconductors to be ferroelectric, with significantly enhanced electrical, piezoelectric, photocatalytic, and quantum properties. These unique characteristics, together with its ultra-wide bandgap, ferroelectric functionality, and seamless integration with III-N technology, promises a wide range of future applications, including high-power and high-frequency electronics, UV optoelectronics, acoustic resonators and filters, micro-electromechanical systems (MEMs), memory electronics, neuromorphic computing, and integrated quantum photonics, to name just a few. In this talk I will present recent advances of ferroelectric Sc-III-nitride heterostructures and nanostructures, including epitaxy, properties and emerging device applications. Molecular beam epitaxy and properties of ScAlN and ScGaN with a wide range of Sc compositions will be discussed. Special attention will be paid to the unique ferroelectric properties of these ultrawide bandgap semiconductors. The realization of ultrathin ferroelectric nitride heterostructures and the underlying physics and properties will be discussed, together with their emerging applications in quantum photonics and electronics.

Biography

Zetian Mi is a Professor in the Electrical and Computer Engineering at University of Michigan. His research interests are in the areas of low dimensional semiconductors and their applications in electronic, photonic, clean energy, and quantum devices. Prof. Mi is a Fellow of IEEE, APS, Optica, and SPIE, and a recipient of the Science and Engineering Award from W. M. Keck Foundation, David E. Liddle Research Excellence Award, IEEE Nanotechnology Council Distinguished Lecturer Award, and IEEE Photonics Society Distinguished Lecturer Award. He is as the Editor-in-Chief of Progress in Quantum Electronics and Vice President for Conferences of IEEE Photonics Society.

Generation and manipulation of frequency states of light with AlGaAs quantum sources

[1]M.Amanti, [1]G. Maltese, [1]F. Appas, [1]G. Sinnl, [2]A. Lemaître, [1]P. Milman, [1]F. Baboux, [1]S. Ducci

[1]Laboratoire Matériaux et Phénomènes Quantiques, Université Paris Diderot, CNRS-UMR 7162, 75013 Paris, France.

[2]Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Sud, Université Paris-Saclay, C2N-Marcoussis, Marcoussis, France.

Abstract

In these last years, a growing attention has been devoted to large-scale entangled quantum states of light as key elements to increase the data capacity and robustness in quantum information protocols. Such states can be realized through qubits encoded in many- particles, but this approach suffers from scalability problems; an alternative strategy is to work with a lesser number of particles and to encode information in high-dimensional spaces. This has been implemented using different degrees of freedom of light: spatial or path modes, orbital angular momentum, time-energy, frequency. Among all these possibilities, the frequency domain is particularly appealing, thanks to its compatibility with the existing fibered telecom network; moreover, it enables the development of robust and scalable systems in a single spatial mode, without the requirement of complex beam shaping or stabilized interferometers.

In this work we present quantum frequency combs as useful resource for parallel quantum communication and processing, given the robustness and easy handling offered by the frequency degree of freedom. We propose a method to generate broadband bi-photon frequency combs and control their symmetry under particle exchange, based on purely passive optical components, such as a cavity and an optical delay line. We experimentally demonstrate our method using an integrated AlGaAs semiconductor platform producing quantum frequency combs, working at room temperature and compliant with electrical injection. We show the generation and manipulation of bi-photon frequency combs, spreading over more the 500 peaks. By finely tuning the CW pumping frequency in an unbalanced Hong-Ou-Mandel interferometer scheme, the spatial wave-function is transformed from bosonic to fermionic. These results demonstrate the ability of our chip to generate and manipulate high-dimensional entangled states and open the way to its utilization in a large variety of quantum information protocols.

Biography

Dr. Amanti is assistant professor at the Université de Paris since 2011. She received her PhD in 2010 at the ETH Zurich in the group of J. Faist on the Photonics of THz Quantum Cascade lasers (QCL). After one year postdoctoral fellowship she joined the group of C. Sirtori where she worked on the high frequency modulation of Mid-infrared QCL. In 2017 she moved her research activities to quantum optics and she joined the group of S. Ducci at the Université de Paris where she is actually working on AlGaAs quantum sources.

Low-Noise Terahertz-Wave Detector: Fermi-Level Managed Barrier Diode

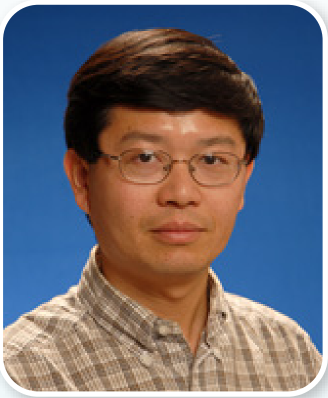
Hiroshi Ito

Institute for Photon Science and Technology, Graduate School of Science, The University of Tokyo, Bunkyo-ku, Tokyo, Japan

Abstract

We developed a InP/InGaAs hetero-barrier rectifier called a Fermi-level managed barrier (FMB) diode. It has stable, reproducible, and uniform characteristics in principle because it consists of a semiconductor hetero-barrier structure. Its low barrier height (around 100 meV) enables both a low differential resistance and high output current under zero-bias conditions. These features are essential for simultaneously achieving a broad bandwidth and low noise-equivalent-power (NEP) detection under zero-bias conditions. The fabricated quasi-optical FMB diode module with an integrated pre-amplifier could detect THz-waves at frequencies from 160 GHz to 1.4 THz with a very low NEP of 3e-12 W/Hz^0.5 at 300 GHz in the direct detection mode. The low barrier height of the FMB diode also decreases the required local oscillator (LO) power in the heterodyne detection to very low levels for obtaining low NEPs. The FMB diode module integrated with a broadband trans-impedance amplifier exhibited an intermediate frequency bandwidth of about 36 GHz and a very low NEP of 3e-19 W/Hz for an LO power of only 7e-5 W at around 300 GHz. The FMB diode is also suitable for constructing an arrayed detector for a THz-wave imaging system because of its very uniform characteristics. A transmission-type imaging system using a linear detector array consisting of 100 FMB diodes was constructed and tested at 315 GHz. Short-time imaging within 0.5 s for 120 x 120 mm^2 area was achieved due to the effect of the arrayed detector configuration as well as the very low-noise characteristics of the FMB diodes.

Recent Progress in Long Wavelength Interband Cascade Lasers



[1]**Rui Q. Yang,** [1]Y. Shen, [1]J. A. Massengale, [2]S. D. Hawkins, [2]A. J. Muhowski

[1]School of Electrical and Computer Engineering, University of Oklahoma, Norman, OK 73019, USA

[2]Sandia National Laboratories, PO Box 5800, Albuquerque, NM, 87185-1085 USA

Abstract

Interband cascade lasers (ICLs) based on type-II quantum well (QW) active regions have achieved excellent device performance at room temperature in the 3 – 6 μm range with low power consumption. Extension of efficient ICLs to longer wavelengths is challenging due to several factors, including reduced wavefunction overlap in the type-II QW and higher free-carrier absorption loss. In this work, we report significant progress in long wavelength (LW) ICLs from newly designed and grown InAs-based ICL wafers. These ICLs operate in the wavelength region from ~10 to beyond 14 μm with threshold current densities as low as 7 A/cm2 and continuous-wave (cw) output powers greater than 100 mW/facet. Compared to previous InAs-based ICLs at similar wavelengths, the operating temperature has been raised considerably. For example, ICLs with InAsP barriers operated in pulsed mode at temperatures up to 210 K near 12.3 μm, 50 K higher than the previously reported LW ICLs. Furthermore, ICLs with innovative active QWs containing InAsP barriers were able to operate at wavelengths near 14.3 μm, the longest ever demonstrated for III-V interband lasers, suggesting great potential of ICLs to cover an even wider wavelength range. More details and updated results will be reported.

Acknowledgements: The work at OU was supported in part by NSF grant ECCS-1931193. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525.

Biography

Rui Q. Yang received the Ph.D. degree in physics from Nanjing University, China, in 1987. He was a Principal Member of Engineering Staff and a Task Manager with Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, where he led the development of advanced interband cascade lasers. In 2007, he joined The University of Oklahoma, where he is currently a Presidential Professor. He has authored or coauthored more than 150 articles in peer-reviewed journals. He is a fellow of IEEE and Optica. He was a recipient of the 2018 IEEE Photonics Society Aron Kressel Award.

Ultrafast plasmon-enhanced deterministically assembled single-photon sources based on nanodiamond color centers

Simeon I. Bogdanov

Department of Electrical and Computer Engineering, Nick Holonyak, Jr. Micro and Nanotechnology Laboratory and Illinois Quantum Information Science and Technology Center, University of Illinois Urbana-Champaign, Urbana, Illinois 61801, USA

Abstract

Color centers in nanodiamonds offer light-matter coupling rates in the near-THz range, and are compatible with any photonic platform. They constitute promising building blocks for high-bandwidth quantum photonics. However, the properties of the color centers and the nanodiamonds themselves are heterogenous. To interface these emitters with the on-chip photonic circuitry one must pre-select and deterministically manipulate them with nanoscale precision. We present a study of fundamental plasmon-enhanced emission rate limits in quantum emitters and a suite of recently developed techniques for realizing deterministically assembled plasmon-enhanced single-photon sources. These techniques include rapid automatic focusing, optical nanoparticle sizing, neural network-driven quantum optical measurements, probe-assisted nanoantenna assembly and the optical control of plasmonic cavity mode volume.

Biography

Simeon Bogdanov obtained his B.Sc. from Ecole Polytechnique in Palaiseau (France) and his M.Sc. from the Royal Institute of Technology in Stockholm (Sweden). He completed his Ph.D. at Northwestern University. He is currently an Assistant Professor of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign. His interests include semiconductor physics, nanoscale and quantum photonics. He is a recipient of the NSF CAREER Award.

DAY 4 | Session 13

Session Chairs:
Dr. Yoshie Otake, Prof. Simeon Bogdanov

Title: Ultra-Broadband Compact Frequency Synthesizers Using Self-Forced Multi-Mode Multi-Quantum Semiconductor Lasers
Dr. Afshin Daryoush, Drexel University, USA

Title: Realization of InGaN nanoLEDs delivering blue, green and red light
Prof. Lars Samuelson, Lund University, Sweden

Title: Interaction of light with non-Hermitian plasmonic nanoresonators: The mode volume
Dr. Philippe Lalanne, CNRS-IOGS-University of Bordeaux, France

Title: Energy-Efficient Integrated Nano-Phototransistors
Prof. Hooman Mohseni, Northwestern University, USA

Ultra-Broadband Compact Frequency Synthesizers Using Self-Forced Multi-Mode Multi-Quantum Semiconductor Lasers

Prof. Afshin S. Daryoush

Department or Electrical and Computer Engineering, Drexel University, Philadelphia, PA, USA

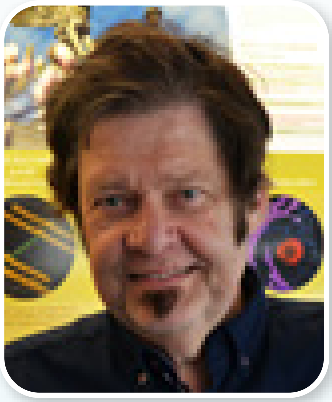
Abstract

Advanced imaging, remote sensing, and telecommunication systems require reliable ultra-high stability local oscillators to achieve high fidelity coherent detection at microwave frequencies. Frequency stabilized local oscillators are required with phase noise of smaller than -120 dBc/Hz at 10kHz offset carrier and low aperture jitters of below 50fs for microwave sources of 10GHz. Self-forced opto-electronic oscillation techniques of self-injection-locked phase-locked loop (SILPLL) employ low loss long optical delays of microseconds for frequency stabilizations through comparison of instantaneous signals and delayed versions. A compact design of multi-mode laser (MML) is presented here by employing self-forced oscillation combined with self-mode locking (SML) of an MML. Proof of concept of this novel approach is reported using a custom designed InGaAsP/InP chip using Smart Photonics foundry service, where multi-quantum well semiconductor optical amplifiers, carrier injection based phase modulator (PM), back and common distributed Bragg reflectors (DBR), and external electro-absorption modulators are designed and physically modeled based on the foundry process design kit. A compact realization of SML-MML is presented with multiple modes to a fixed intermodal frequency, where the beat notes of the intermodal oscillation are generated over X-band to form a frequency synthesizer. The PM bias control of two MLL lasers with common DBR is used to tune this opto-electronic oscillator from 11GHz to 13GHz with a frequency resolution of 110kHz. Self-forced oscillation techniques of SILPLL combined with SML has provided frequency synthesis with aperture jitter improved from 58ps for the free-running MML to 68fs when 5 modes are correlated using SILPLL and SML. In addition, as the number of self-mode-locking modes to 201 modes reach timing jitters of less than 1fs over full frequency synthesis of X-band. A patented self-forced MML is discussed with fully integrated optical delays using cascaded add-drop filters that are realized by 2D photonic crystal ring resonators with defects.

Biography

Dr. Afshin Daryoush studied electrical engineering at Case Western Reserve University, Cleveland, USA (1981) and Drexel University, Philadelphia, USA (1986). He joined Drexel University in 1987 as DuPont Assistant Professor. He was summer Faculty fellow at NASA (1987, 1988) and NADC (1989, 1990). He spent his sabbatical leaves at NTT Wireless Communications Laboratories-Yokosuka, Japan (1996-1997) and IEMN-Lille, France (2005). He is full-professor and Fellow of IEEE since 1999. Prof. Daryoush is member of the Committee Science & the Arts of the Franklin Institute, Philadelphia, USA. He has published over 300 scientific papers, 10 book chapters, and has received 22 patents.

Realization of InGaN nanoLEDs delivering blue, green and red light



Lars Samuelson

[1]Department or Solid State Physics, NanoLund, Lund University, Lund, Sweden.

[2]Department or Electrical and Electronic Engineering, SUSTech, Shenzhen, China

Abstract

The large lattice mis-match between red-emitting active layers, with at least 35% indium in InGaN QWs, and the GaN substrate still limits the efficiencies to very low values, typically well below 5%. We propose to use seeding techniques originally developed for nanowire growth, to seed the formation of ternary InGaN pyramids which later are converted to thin c-facet platelets of InGaN. The top-facet of each such template is on the scale of 250nm to 1.5µm, thus better described as templates for nanoLEDs. These can either be used as single nanoLED used as a pixel or as an array of such nanoLEDs, constituting a complete microLED pixel.

Biography

Lars Samuelson got his PhD in Physics at Lund University in 1977, then post-doc at IBM in California. He became Professor at Chalmers in 1986 and at Lund University in 1988, then initiating NanoLund, today engaging more than 300 scientists. He is member of the Royal Swedish Academy of Sciences (Physics) and of Engineering Sciences. Since 2021 Distinguished Professor at SUSTech, Shenzhen, China. He is author of >700 articles, h-index 86, listed in the top 1% highly cited researchers by Web-of-Science, and has given >300 plenary/invited talks at international meetings. He is Founder of four start-up companies engaged in commercialization of nanomaterials technologies.

Interaction of light with non-Hermitian plasmonic nanoresonators: The mode volume

Tong Wu and **Philippe Lalanne**

Laboratoire Photonique, Numérique et Nanosciences (LP2N), CNRS-IOGS-Univ Bordeaux, Bordeaux, France

Abstract

Nanoresonators enhance many light-matter-interaction processes and are used in various modern applications in nano-quantum optics. They are open systems and their eigenstates are always leaky and have a finite lifetime, even when they are dark states. The analysis of the non-Hermitian behavior of tiny nanocavities posed great difficulty in the past, but the situation has changed drastically recently thanks to recent progresses in the complex analysis of open electromagnetic systems [1]. Quite reversely, we have now reached a point where non-Hermitian freeware package now exist to compute and normalize the resonance states to model how light interact with them.

The physics of non-Hermitian systems is significantly richer than that of Hermitian ones. We will present a mathematical formalism based on the notion of quasinormal modes and of their complex mode volume [2], which comprehensively helps understanding key phenomena observed in nanocavities. For instance, we will explain why highly non-Hermitian modes may reduce (instead of increase as usually expected in Hermitian system) the total radiative damping of an emitter in a cavity, i.e. the LDOS. We will also explain how the imaginary part of the mode volume, which is quite counterintuitive, may be measured and what is its significance in the non-Hermitian perturbation theory of cavities.

[1] P. Lalanne et al., "Light interaction with photonic and plasmonic resonances ", Laser & Photonics Reviews 12, 1700113 (2018).

[2] T. Wu, M. Gurioli, P. Lalanne, "Nanoscale Light Confinement: the Q's and V's", ACS Photonics 8 (6), 1522-1538 (2021).

Biography

Philippe Lalanne is a research scientist at CNRS (Centre National de la Recherche Scientifique), working at Institut d'Optique d'Aquitaine. He received his PhD from Université Paris-Sud in 1989. He is an expert in nanoscale electrodynamics, with an emphasize on modelling and theory. His current research is devoted to understanding how light interacts with subwavelength structures to demonstrate novel optical functionalities. He has launched new modal theories and has pioneered the development of large-NA metalenses with high-index nanostructures. He is a Fellow of the Optical Society of America, the SPIE, and the Institute of Physics.

Energy-Efficient Integrated Nano-Phototransistors

Hooman Mohseni

Electrical and Computer Engineering, Northwestern University, Evanston, IL, USA

Abstract

It is speculated that energy consumption represents the biggest barrier for emerging computation and sensing technologies, including advanced machine learning, large-scale quantum computing, and broadband brain-machine interface. This limitation is already evident for large and small scale systems, from data centers to wearables and IoT. We theoretically show the fundamental advantage of nano-structured optoelectronics, and experimentally present results from nano-optoelectronic devices integrated into systems with record energy efficiencies.

Biography

Hooman Mohseni is the AT&T Chair Professor of Electrical and Computer Engineering and Professor of Physics and Astronomy at Northwestern University. He is the recipient of several research and teaching award including W.M. Keck Foundation Award, NSF CAREER Award, DARPA Young Faculty Award, and Northwestern Faculty Honor Roll. Mohseni has served at many international conference committees, scientific review panels, and editorial boards. He has published over 260 articles in major journals including Nature and Nature Photonics. Mohseni has been involved in several startups as founder and CTO, including Kernel. He holds over 33 issued US and International patents and patent applications. He is a Fellow of SPIE and OSA.

DAY 4 | Session 14

Session Chairs:
Prof. Afshin Daryoush, Prof. Henri-Jean Drouhin

Title: Nanoscale Light Emitters and their Dynamics
Dr. Yeshaiahu (shaya) Fainman, University of California San Diego, USA

Title: Second harmonic generation with wavefront control on dielectric metasurfaces
Prof. Giuseppe Leo, Université de Paris - CNRS, Paris, France

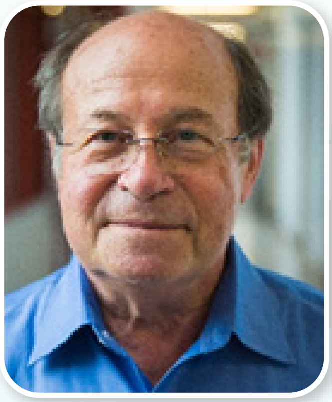
Title: Antimonide-based Narrow Bandgap Semiconductors for Infrared Technology and Quantum Information Science
Dr. Binh-Minh Nguyen, HRL Laboratories, LLC, USA

Title: Photovoltaic Conversion by Reciprocity
Dr. Jean-Francois Guillemoles, CNRS-Ecole Polytechnique/IPParis-ENSCP/PSL-IPVF/SAS, France

Title: Detectors and Emitters for Mid-Wave Infrared Optical Communications
Prof. Vijaysekhar Jayaraman, Praevium Research Inc., USA

QUEST 2023

Nanoscale Light Emitters and their Dinamics



Yeshaiahu (shaya) Fainman and Sizhu Jiang

Departmentof Electrical and Computer Engineering,
University of California San Diego, La Jolla, California, USA

Abstract

We will discuss nanoscale metal-dielectric-semiconductor resonant gain geometries to create a new type of light emitters focusing on three key aspects: second order intensity correlation characterizations, direct modulation and coupled nanolasers dynamics.

Biography

Shaya Fainman is Cymer Chair and Distinguished Professor in ECE at the University of California, San Diego. He received Ph. D. from Technion in 1983. He is directing research of the Ultrafast/ Nanoscale Optics group and made significant contributions to near field optical phenomena. His current research is in near field optical science and technology with applications to information technologies. He contributed over 330 manuscripts in peer review journals. He is a Fellow of the OSA, IEEE, SPIE, and a recipient of SPIE Gabor Award, OSA Emmett N. Leith Medal and OSA Joseph Fraunhofer Award/Robert M. Burley Prize.

Second harmonic generation with wavefront control on dielectric metasurfaces

Carlo Gigli[1], Davide Rocco[2], Adrien Borne[1], Julien Claudon[3], Jean-Michel Gerard[3], [2]Costantino De Angelis, and [1]**Giuseppe Leo**

[1]*Matériaux et Phénomènes Quantiques, Université de Paris - CNRS, Paris, France*

[2]*Department of Information Engineering, University of Brescia, Brescia, Italy*

[3]*Université Grenoble Alpes & CEA-IRIG-PHELIQS, Grenoble, France*

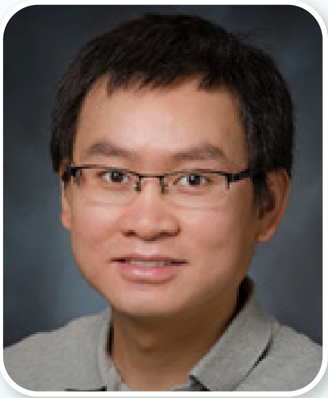
Abstract

All-dielectric nonlinear metasurfaces have recently brought harmonic generation to sub-wavelength level, with spectral and polarization control unachievable in bulk crystals. Not only does nonlinear meta-optics define a field for investigating nonlinear physics at the nanoscale, but it also opens promising application perspectives. Compared to plasmonics, where the electric field is strongly confined close to the metal surface, the electric field of the resonant modes in dielectric nanoparticles penetrates deep inside their non-dissipative volume, enhancing intracavity light-matter interactions and their nonlinear optical response. In my presentation, based on the (2) fully tensorial features of AlGaAs metasurfaces, we propose a robust method to generate 0-2 phase-encoded second harmonic light for nonlinear wavefront shaping, experimentally demonstrating nonlinear beam steering and all-dielectric meta-lenses that generate and focus second harmonic beams to sub-wavelength spot sizes. Nonlinear generation with record efficiency and phase control are achieved in nanostructured arrays which are fully compatible with mature III-V semiconductor technology. This breakthrough paves the way to the development of ultrathin free-space photonic devices for nonlinear imaging, including night vision. Current performances are limited by both design (exploration of a restricted number of geometrical parameters) and fabrication (proximity effects and deviations between the size of nominal and fabricated nanostructures). In the future, design might be improved with machine-learning approaches, and fabrication by more advanced lithographic equipment.

Biography

Giuseppe Leo (1966) received a Laurea degree cum laude in Electronic Engineering at Università La Sapienza, Rome (1990) and a PhD in Physics at Paris-Sud University (2001). A former associate professor at Università Roma Tre and visiting scientist at CSELT and Thomson-CSF, he is currently full professor at Université de Paris, where he is in charge of the Nonlinear Photonics group of the MPQ Laboratory. OSA Fellow since 2019, his research includes nonlinear optics and nanophotonics. He coauthored ≈130 articles on peer-review journals, >270 conferences (of which 84 invited and 3 keynote) and 4 patents, with ≈3600 citations and h-35.

Antimonide-based Narrow Bandgap Semiconductors for Infrared Technology and Quantum Information Science



Binh-Minh Nguyen

HRL Laboratories, LLC, Malibu, California, USA

Abstract

Antimonide-based III-V semiconductors form an unique group of narrow bandgap materials as they are relatively mature to yield high-quality devices and are fab-compatible at industry foundries, yet still have many unanswered fundamental and scientific questions to investigate. Their small energy gap (<0.3 eV) corresponds to optical transitions in the infrared and terahertz regime which have tremendous potential in applications such as detectors, lasers, photovoltaic cells, spectroscopy, etc. In parallel, these narrow-gap compound semiconductors, comprised of large constituent atoms with intrinsically large spin orbit coupling, offer a great deal of advantages in semiconductor-based qubit technologies and spintronics.

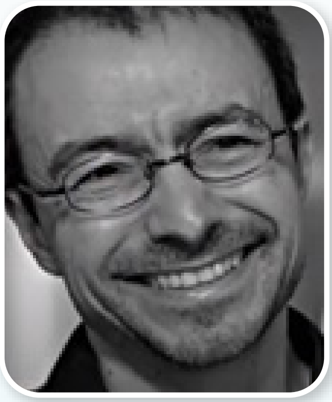
In the field of infrared detection and imaging, antimonide-based materials have emerged as a serious alternative to the incumbent state-of-the-art Mercury Cadmium Telluride due to its superior "–ilities": uniformity, stability, scalability, manufacturability, affordability. I have had the privilege to witness and contribute to its development from an embryonic phase of academic research and prototyping to the industrial adoption and maturation. Examples of both academic's first and best demonstrations and industry's application-focused R&D will be presented in the first half of the talk.

The latter half of the talk will address a fundamental research aspect of Antimonide-based quantum well structures and the role of materials research in quantum information science. InAs/GaSb quantum well is predicted to possess a quantum spin Hall state, where the bulk of the material is electrically insulating and the electrical current running along the edge is fully spin-polarized. In such a regime, it could host a Majorana zero mode, a quantum state that is topologically protected from ambient perturbation, and thus can be registered as error-free logical qubits. Another attractive venue for this quantum well structure is the hybrid with conventional superconductors to form voltage-controllable field effect superconducting transistors. This type of devices leverages the gate-tunability and manufacturability of semiconductor integrated circuitry to address the scalability challenges of state-of-the-art superconducting qubits. Current progress in the field and opportunities will be briefly discussed.

Biography

Dr. Binh-Minh (Minh) Nguyen is a Senior Scientist in the Sensors and Electronics Laboratory at HRL Laboratories where he manages R&D portfolio on antimonide-based semiconductor for infrared sensing technology and quantum materials. Nguyen received his Diplôme de l'Ecole Polytechnique in 2007 and PhD in Electrical Engineering from Northwestern University in 2010. His expertise includes device modeling/design, epitaxial growth, device fabrication and testing. Nguyen has authored/co-authored six book chapters and over 90 technical papers with over 3500 citations and an h-index of 37. He is a Senior Member of SPIE and IEEE.

Photovoltaic Conversion by Reciprocity



JF Guillemoles

[1]IPVF UMR 9006, CNRS-Ecole Polytechnique/IPParis-ENSCP/ PSL-IPVF/SAS 18 boulevard Thomas Gobert - 91120 Palaiseau, France.

Abstract

The development of advanced photovoltaic devices, including those that might overcome the single junction efficiency limit, as well as the development of new materials, all rely on advanced characterization methods. Among all the existing methods, optically based ones are very well adapted to probe quantitatively optoelectronic properties at any stage. We here present the use of multidimensional imaging techniques that record spatially, spectrally and time resolved luminescence images. We will discuss the benefits (and challenges) of looking into direct photon energy conversion systems through some examples, mostly drawn from halide perovskite materials and device. These examples will help visit questions related to efficient transport and conversion in solar cells, as well as questions related to chemical and operational stability of the devices.

Biography

JF Guillemoles is a CNRS Research Director, head of the IPVF joint lab (CNRS- E. Polytechnique- ENSCP-and SAS IPVF), Paris-Saclay (France) aiming at the development of photovoltaics, and former director of a joint lab with the University of Tokyo, NextPV. Scientifically active on high efficiency concepts for solar energy conversion, new applications for photovoltaic, luminescence-based characterization techniques (esp. Hyperspectral imaging), and modeling of photovoltaic materials and devices. Part time Professor at Ecole Polytechnique, author/co-author of more than 400 publications (peer-reviewed papers, book chapters, patents, proceedings ...), editor for Progress in Photovoltaics (Wiley) and EPJPV (EDP), and director of several large R&D programs, such as PEPR TASE.

Scientific production available on ORCID (0000-0003-0114-8624), HAL, and Researchgate

Detectors and Emitters for Mid-Wave Infrared Optical Communications

[1]V. Jayaraman, [1]B. Kolasa, [1]C. Burgner [2]R. Marsland, [2]B. Knipfer, [3]M. Turville-Heitz, [3]J. Ryu, [3]L. J. Mawst, [3]D. Botez, [4]C. L. Canedy, [4]E. M. Jackson, [4]R. L. Espinola, [4]C. S. Kim, [4]E. H. Aifer, [4]I. Vurgaftman, [4]J.R. Meyer

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[2]Intraband, LLC, 505 S. Rosa Road, Suite 34, Madison WI 53719

[3]Department of Electrical and Computer Engineering, U. Wisconsin, Madison WI 53706

[4]Naval Research Laboratory, Washington DC 20375

Abstract

Free space optical communication links in the 3- m and 8-12 m wavelength bands address a growing need for high-data rate, low-latency, and secure wireless communications operating outside the regulated and crowded rf frequency bands. This will serve applications ranging from vehicle automation to ad-hoc battlefield command and control. MWIR and LWIR wavelengths offer significantly less attenuation in haze, dust, and turbulence relative to near-IR (~1.55 m) wavelengths. With the exception of fog and clouds, MWIR systems share the advantages of LWIR, and further benefit from higher-performance lasers and detectors as well as reduced diffraction. In this paper we discuss critical detector and source components in a 4.6 m MWIR optical communication system. The work includes the design, fabrication, and performance of resonant cavity infrared detectors (RCIDs) that operate with high quantum efficiency, low dark current, and multi-GHz response, as well as high power, narrow linewidth, buried heterostructure (BH) distributed feedback (DFB) quantum cascade lasers (QCLs) with multi-GHz modulation speed. RCIDs employ multi-pass absorption in a thin absorber inside a resonant cavity, to simultaneously provide both low dark current and high quantum efficiency. Our RCIDs employ GaSb-based nBn detectors that are wafer-bonded to thick GaAs/AlGaAs mirrors to provide a commercially viable RCID solution that is scalable across MWIR and LWIR wavelengths. The RCID's narrow spectral response can also be tuned across multiple communication channels by dynamically adjusting the cavity length. The paper will also discuss the projected performance of communication links based on these QCL and RCID devices.

Biography

Dr. Vijaysekhar Jayaraman received the BS/MS degree from the Massachusetts Institute of Technology in 1985, and the PhD from the University of California at Santa Barbara (UCSB) in 1994, in electrical engineering. At UCSB, he demonstrated the first widely tunable sampled grating distributed bragg reflector (SGDBR) lasers, which have since been widely deployed in wavelength division multiplexed (WDM) fiber-optic communications. Dr. Jayaraman is the founder of Praevium Research, which is currently focused on MEMS-tunable vertical cavity lasers (MEMS-VCSELs) for medical imaging and mid-infrared resonant cavity detectors for communications. Praevium MEMS-VCSELs have produced record tuning ranges and speeds from 800-3400nm.

DAY 4 | Session 15

Session Chairs:
Dr. Olivier Acher, Prof. Pedram Khalili

Title: Nanophotonics: from phonon confinement to topological protection
Prof. Clivia Sotomayor Torres, ICREA and Catalan Inst. Nanoscience and Nanotechnology, Spain

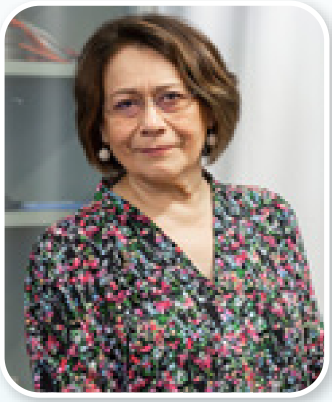
Title: Advanced Quantum Sensors: Superluminal Lasers, Subluminal Lasers and Schroedinger Cat Atomic Interferometers
Prof. Selim Shahriar, Northwestern University, USA

Title: Overview of SLS-Based Instrument Development at NASA/Goddard Space Flight Center
Dr. Murzy Jhabvala, NASA Goddard Space Flight Center, USA

Title: New Disruptive Solar-blind UVC Sensors for New Space Applications
Dr. Luc Dame, Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS), IPSL/CNRS & University Paris-Saclay, France

Title: Electric-field induced nonlinear optics in CMOS silicon nanophotonic waveguides
Dr. David Heydari, Stanford University, USA

Nanophononics: from phonon confinement to topological protection



Clivia M. Sotomayor Torres

ICREA and Catalan Inst. Nanoscience & Nanotechnology, Bellaterra, Spain

Abstract

Phonons are less common in the scientific discourse compared to electrons and photons. Yet, they offer the potential for low energy information transport, suitable for advanced interconnect , which will be addressed here.

Starting with phonon confinement in free-standing ultra-thin Si membranes, exploring engineering of dispersion relations to obtained functional 2D phononic crystals, I will illustrate how progress has been made coupling phonons to photons in optomechanical systems towards phonon sources and waveguides above 12 GHz. A variety od designs will be explained using the interplay between phonons and photons as well as phonon transport and localisation

I will conclude with our recent endeavours to achieve topological protection in phononic waveguides. We based our designs in the Valley Hall effect, achieving Dirac cones, opening the band gap and realising gap modes. Our experimental work is anchored in scalable Si-based laboratory-scale devices operating a room temperature.

The results to be presented arise from years-long collaborative research.

Biography

Prof. Dr. Clivia M. Sotomayor Torres studied Physics at Southampton University and obtained her PhD in Physics in 1984 from the University of Manchester, UK. She held tenured academic appointments at Saint Andrews and Glasgow universities (UK) and at Wuppertal University (Germany). Later she was a research professor at the National University of Ireland University College Cork (Tyndall National Institute). Since 2007 she is an ICREA research professor at the Catalan Institute of Nanoscience and Nanotechnology in Spain. Her research is mainly focused on nanophononics. She is member of the Academia Europaea and holder of an ERC AdG investigating phonons for information and communication technologies.

Advanced Quantum Sensors: Superluminal Lasers, Subluminal Lasers and Schroedinger Cat Atomic Interferometers

[1,2]Selim M. Shahriar

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[2]Department of Physics and Astronomy, Northwestern University, Evanston, IL, USA

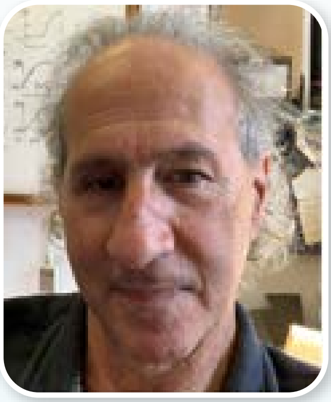
Abstract

Critically tuned anomalous dispersion produces conditions under which the group velocity of light in a laser can far exceed the vacuum speed of light, without violating causality or relativity. This is called a superluminal laser. For such a laser, the spectral sensitivity to a change in the length of the cavity is enhanced by a factor of as much as a million. I will describe how the superluminal laser can be used to realize ultrasensitive gyroscopes and accelerometers, with potential application to GPS denied navigation. A large area superluminal gyroscope is also expected to be sensitive enough to measure terrestrially the gravitational frame dragging effect, known as Lens-Thirring rotation, as a high-precision test of General Relativity. It is also possible to reverse the slope of the dispersion to realize a subluminal laser, which is extremely insensitive to change in the cavity length. I will discuss the prospect of using the subluminal laser for a range of applications, including dark matter detection. Finally, I will describe our work on the development of a Schroedinger cat atomic interferometer, which makes use of a maximally-entangled quantum state of an atomic ensemble, generated via cavity-induced spin-squeezing. For a gyroscope based on such an interferometer, employing a hundred million atoms, the collective matter-wave behaves as an oscillating field with a frequency of nearly a decillion Hz. As such, the sensitivity scale of such a gyroscope is nearly fifteen orders of magnitude higher than that of a conventional optical gyroscope. I will describe challenges in realizing such a sensor, and potential application thereof to GPS-denied navigation and test of General Relativity.

Biography

Dr. Selim Shahriar is a Professor in the Department of Electrical and Computer Engineering and the Department of Physics and Astronomy at Northwestern University. He is also the Director of the division of solid-state, photonics and quantum technologies within ECE. Dr. Shahriar received his Ph.D. from MIT in 1992. He has published 632 papers, including 294 in peer-reviewed journals. His work has been cited more than 68000 times, and he has an H-index of 88. His research interests include Applications of Slow and Fast Light, Quantum Computing with Trapped Atoms, Gravitational Wave Detection, Tests of General Relativity, Holographic and Polarimetric Image Processing, Atomic Clocks, Atom Interferometry, and Spin Squeezing. In 2016, for his contribution to the first detection of gravitational waves, he was a co-recipient of the Gruber Prize in Cosmology and the Special Breakthrough Prize in Fundamental Physics. He is a member of the LIGO Scientific Collaboration and a Fellow of SPIE and Optica (formerly OSA).

Overview of SLS-Based Instrument Development at NASA/Goddard Space Flight Center



Murzy Jhabvala

Instrument Systems and Technology Division, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Abstract

Advances in GaSb/InAs Strained Layer Superlattice (SLS) Infrared Photodetector (IR) technology have been noteworthy. Major improvements in detector sensitivity, array size and format have been made in a relatively short span of time and now provide unique scientific instrumentation opportunities. We have designed and fabricated a wide range of SLS-based imaging systems that are telescope facility instruments, flown on aircraft and most recently deployed on the International Space Station as an attached payload performing Earth observations collecting over 15 million images in two infrared bands. This presentation will describe recent advances in infrared imaging (IR) instruments using a variety strained layer super lattice (SLS) detector arrays. Instruments include broadband portable camera development, multiband portable cameras, imaging system on the International Space Station and on-going and near-term future instruments. The applications for these instruments are remote sensing of a multitude of Earth climate parameters including, land surface temperature, evapotranspiration, global ice and permafrost monitoring, biomass burning and wildfire detection, agricultural information, water distribution and pollution to list a few key parameters. A description of the various SLS detector formats and performance measurements will be presented along with the subsequent instrument fabricated. Results from numerous operational campaigns in the lab, in the field, airborne and space will be presented. Future applications will be described by further reducing size, weight and power to enable this technology to ultimately perform Landsat type Earth monitoring with a constellation of cubesats.

Biography

Dr. Jhabvala has been working in the field of semiconductors for 50 years. He has pioneered the development of new transistor structures, radiation hardened PMOS and CMOS integrated circuits for satellite applications, microfilament blackbody sources, new infrared detectors, new imaging systems, and an assortment of new and unique medical devices. He has led and driven the development of advanced detector technologies that has increased NASA's overall technical and science capabilities. He has contributed to over 30 NASA missions ranging from the very early International Sun Earth Explorer and the Cosmic Background Explorer to the Hubble Space Telescope, Spitzer Space Telescope, Solar and Heliospheric Observatory, Landsat 8/9, OSIRIS-REx, Euclid and led the microshutters development for the Webb Space Telescope. He led the develpment of the SLS-based instrument on the International Space Station. He has over 180 publications.

Low-Noise Terahertz-Wave Detector: Fermi-Level Managed Barrier Diode

[1]Luc Damé, [1]Mustapha Meftah, [1]Halima Ghorbel, [1]Pierre Gilbert, [1]Xavier Arrateig, [2]Pierre Maso, [3]David Rogers, [3]Philippe Bove, [3]Vinod Sandana, [3]Ferechteh Teherani

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Abstract

UV Space Astronomy covers a number of fields including Solar Physics, Heliospheric Physics, Space Weather studies, Earth observations, solar UV variability influence on climate and ozone monitoring, to name a few. However and surprisingly, the functional lifetime of the silicon-based UV sensors commonly used in Space is typically of only several weeks or months due mainly to radiation and contaminant trapped by their cooled surfaces. Contamination is the result of hydrocarbon outgassing of satellites (fuel deposits, solar panels...) which create deposits on cooled detectors that polymerize under UV illumination, degrading lifetime and performance. Compact solid-state photodetectors based on -Ga_2O_3 and MgZnO show very low dark currents, permitting room temperature operation, which suppresses the need for a cooling system (mass and power savings) and avoids the cold surface that traps environmental contamination. Moreover, both fcc MgZnO and -Ga_2O_3 (alloyed with Al in order to boost the bandgap) offer the deeper UV operation that is required to achieve solar-blindness above the Earth's ozone creation layer in the stratosphere (UVC sensitivity in the Herzberg continuum between 200 and 242 nm). Other key assets for space applications are the far superior radiation hardness of these oxides (to resist the harsh space environment) and the high gain of these devices which allow operation at lower voltages (lower power) of 5 Volts only (compatible with cubesat platforms). These UVC Herzberg continuum dedicated detectors are under realization (protoflight model tests and performances will be presented) and will be flown on the INSPIRE-7 nanosatellite in 2023. Ultimately we plan to integrate these disruptive detectors on dozens of future solar and climate satellites constellations ventures.

Biography

PhD Thesis in Astrophysics, Paris 7 University and D. Ing Thesis in Astronomy and Space Technics, Paul Sabatier Toulouse University. Involved in the definition and design of several proposed solar, Space Weather and climate investigations for high resolution UV imaging, spectroscopy, coronagraphy and oscillations over the past 40 years (PI of ESA/NASA GOLF/SOHO global oscillations experiment, PI of CNES/PICARD microsatellite, Instrument Scientist of the ESA/PROBA-3 ASPIICS coronagraph mission, etc.). More recently, Mission Leader of the SoSWEET-SOUP (SOlar, Space Weather Extreme EvenTs and Stratospheric Ozone Ultimate Profiles) constellation mission, implementing the carbon-carbon & SiC SUAVE telescope, and responsible of disruptive new oxide-based UVC detectors to be flown on the INSPIRE-7 nanosatellite in 2023. Over 250 publications (80 in peer review journals).

Electric-field induced nonlinear optics in CMOS silicon nanophotonic waveguides

[1]**David Heydari**, [2]Mircea Cătuneanu, [1,3]Edwin Ng, [4]Dodd J. Gray, Jr., [3,4]Ryan Hamerly, [1]Jatadhari Mishra, [1,3]Marc Jankowski, [1]M. M. Fejer, [2]Kambiz Jamshidi, and [1]Hideo Mabuchi

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[4]*Research Laboratory of Electronics, Mass. Inst. Tech., 50 Vassar Street, Cambridge, Mass. 02139 USA*

Abstract

The microelectronics industry is foundationally built on silicon-based semiconductor devices. Silicon photonics, a relatively nascent yet rapidly emerging field, leverages the maturity of CMOS foundry processes and promises dense integration of optical functionality like that of microelectronic circuits. However, silicon's inability to produce gain or lase has presented a major barrier to developing fully integrated silicon-based optoelectronic devices. In parallel, nonlinear optics has made substantial advances in expanding the range of accessible frequencies of optical sources, yet as a field has evolved largely independently of silicon-based materials. By combining the principles of nonlinear optics with scalable, high-quality linear optical elements enabled by silicon photonics, such as waveguides, and electronic devices, such as CMOS-based diodes, all on-chip, the latitude of the optoelectronic functionality of silicon can be significantly enhanced. However, nonlinear optical processes such as sum frequency generation and optical parametric amplification, which rely on the second-order susceptibility, are forbidden in silicon, due to its crystalline inversion symmetry. This symmetry can be broken with an applied electric field, a process known as electric field induced second harmonic generation, which is effectively derived from the third-order susceptibility of a material and can be understood as four-wave mixing between two optical electromagnetic fields, one DC field, and a resultant optical field. Moreover, quasi-phase matching allows for efficient power transfer between these fields, which can be implemented in silicon using periodically-poled DC fields generated by reverse-biased PN diodes. In this presentation, I will discuss the design and characterization of devices that utilize industry-ready silicon photonics foundry processes to realize nonlinear optics on-chip via second harmonic generation and the first (second-order) optical parametric amplifier on silicon.

Biography

David HEYDARI received the BS and MS degrees from Northwestern University (Evanston, Ill., United States) in 2016, under the direction of renowned Professor Manijeh RAZEGHI, who leads the Center for Quantum Devices. He recently defended and will receive the PhD degree from Stanford University (Stanford, Calif., United States) in 2023. He is currently undertaking a postdoctoral fellowship in the same group where he did his PhD with Professor Hideo MABUCHI, known for his pioneering work in quantum feedback.

DAY 4 | Session 16

Session Chairs:
Prof. Giti Khodaparast, Prof. Linda J Olafsen

Title: Towards Fermionic Systems Simulations on Quantum Computers with Myqlm-Fermion
Dr. Maxime Oliva, Atos Quantum Lab, Atos, Les Clayes-Sous-Bois, Yvelines, France

Title: Quantum Computing Logic – an example for Quantum Genomics
Dr. Bertels Koen, University of Ghent and QBee.eu, Belgium

Title: Exciton Fine Structure in Lead Chalcogenide Quantum Dots: Interplay between Valley Mixing and Exchange Interaction
Dr. Mikhail Nestoklon, TU Dortmund, Germany

Title: Nonlinear ultrafast terahertz studies at the TeraFERMI beamline
Dr. Paola di Pietro, Elettra-Sincrotrone Trieste S. C. p. A., Italy

Title: An advanced RF timer of single electrons and photons
Dr. Amur Margaryan, A. I. Alikhanyan, National Science Laboratory, Armenia

Title: To-tier resources: Light: Science & Applications, eLight and Light: Advanced Manufacturing
Dr. Chenzi Guo, CIOMP, Chinese Academy of Sciences, China

Towards Fermionic Systems Simulations on Quantum Computers with Myqlm-Fermion

Maxime Oliva

Atos Quantum Lab, Atos, Les Clayes-Sous-Bois, Yvelines, France

Abstract

The apparently intrinsic complexity of simulating many-body systems on classical computers has led to the emergence of many approximation methods, but the complexity of quantum systems remains hard to appease. Quantum computers bring exciting new methods to tackle these challenges, especially in quantum chemistry, where new quantum algorithms could lead to efficient resolution of previously unreachable fermionic system sizes.

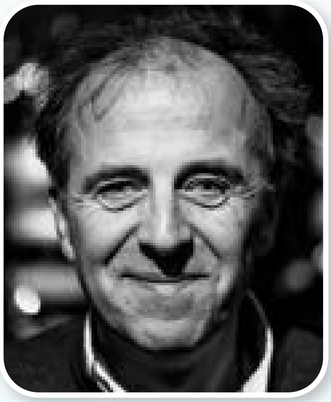
At Atos, we have built a quantum software stack for writing, simulating, optimizing, and executing quantum programs. Among the many applications we provide, we have developed the open-source library MyQLM-fermion. The aim of this library is to simplify the resolution of spin and fermionic systems on quantum computers, by providing tools which include fermion to qubits mapping, trotterization or phase estimation, as well as multiple ansatze and optimizers. This library along with the QLM framework not only allows the resolution of fermionic systems on quantum machines, but also the exploration of other areas of quantum computing, and how they can benefit quantum chemistry. You can for example study the impact of the various compilers we provide on your ansatze to increase performance, simulate a noisy quantum computer with a custom noise model to see how noise affects the resolution of a known molecule, or simply implement your own algorithm as a plugin in the QLM.

Throughout this presentation, we will first introduce fermionic systems, their formalism, and how they can be mapped onto quantum computers. We will then demonstrate the MyQLM-fermion library capabilities for several use cases.

Biography

Dr. Oliva studied fundamental physics at Toulouse in France and graduated as MSc in 2015. He then underwent a PhD under the supervision of Dr. Steuernagel at the University of Hertfordshire in UK. He was awarded his PhD in 2019. He is now working in Atos quantum division as a R&D engineer and is the main developer of MyQLM-fermion.

Quantum Computing Logic - an example for Quantum Genomics



Koen Bertels

[1]University of Ghent, Belgium

[2]QBee.eu, Leuven, Belgium

Abstract

Even though still a lot of work needs to be done a the quantum physical level to produce really good qubits, it is also becoming urgent to start developing, developing and testing quantum algorithms for a wide variety of important scientific and industrial applications. One example on which we have already worked is based on genome sequencing, for which we have already developed a quantum version. In order to abstract away from the errors physical qubits still have, we are using perfect qubits. This approach is labelled the PISQ-methodology. We assume that qubits do not decohere and make correct quantum operations. We will show the results and even give a short demo of the algorithm.

Biography

Koen Bertels' research focuses on quantum computing and more specifically on the definition and implementation of a scalable quantum computer system for any scientific and operational field. He is currently building a new team to continue working on all layers of the full stack which has been my work from the first day working on quantum computing. He has now moved to the use of perfect qubits, which has no decoherence and no errors in the quantum gates. We call this the PISQ-methodology, where PISQ stands for Perfect (qubits) Intermediate Scale Quantum computing.

Exciton Fine Structure in Lead Chalcogenide Quantum Dots: Interplay between Valley Mixing and Exchange Interaction

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Exciton Fine Structure in Lead Chalcogenide Quantum Dots: Interplay between Valley Mixing and Exchange Interaction

Lead chalcogenide quantum dots (QDs) have attracted significant scientific and technological interest due to the photoluminescence over a wide infrared wavelength range, which is tuneable by the QD size. Electron and hole states in bulk lead chalcogenides are eight-fold degenerate by the valley and spin index. In QDs, the 64-fold degeneracy of the excitons is lifted by the interplay of the valley mixing and the electron–hole exchange interaction. We calculate the exciton fine structure in the framework of the empirical tight-binding (ETB) method and thoroughly investigate the relative importance of the inter-valley, spin-orbit, and electron-hole exchange couplings for the splittings. We also construct the effective model in the framework of k·p approximation to describe and explain the results of the atomistic calculations.

First, the single-particle band-edge electron and hole states are computed in QDs of various shape. The 8-fold degeneracy is partially lifted by the inter-valley scattering at the surface, resulting in three levels with energy separations depending on the size and shape of QDs. Second, we use the configuration interaction method to obtain the excitonic states and compute optical absorption spectra fully accounting for the exciton fine structure within the ETB. Finally, within the k·p approach, the intervalley and Coulomb interactions are treated as first-order perturbations to the electron and hole states quantized in QD and the oscillator strengths of the excitonic states are calculated. The comparison of the atomistic calculations with the effective model allows to disentangle the valley mixing and exchange interactions.

Using the original k·p model, we demonstrate that intervalley electron–hole exchange interaction, ignored in previous studies, dramatically modifies the exciton fine structure and leads to appearance of the ultrabright valley-symmetric spin-triplet exciton state dominating interband optical absorption. Valley mixing leads to brightening of other symmetry-allowed spin-triplet states which dominate low-temperature photoluminescence.

Biography

Dr. Nestoklon studied physics at the Saint-Petersburg State Polytekhnical University, Russia and graduated as MS in 2003. During the education at the University, he joined the research group of Prof. Ivchenko at the Ioffe Institute. He received his PhD degree in 2006 at the same institution and got a permanent position in Ioffe Institute. After PhD, he also worked as a guest researcher in group of Prof. Voisin, Laboratoire de Photonique et Nanostructures, CNRS, France. Since 2022, he works in Technische Universität Dortmund. He has published more than 60 research articles in SCI(E) journals.

Nonlinear ultrafast terahertz studies at the TeraFERMI beamline

[1]P. Di Pietro, [1]N. Adhlakha, [1]J. Schmidt, [1]F. Piccirilli, [2]S. Oh, [3]A. Di Gaspare, [4]P. Orgiani, [5]S. Lupi, [1]A. Perucchi

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[2]Department of Physics and Astronomy Rutgers, State University of New Jersey, 136 Frelinghuysen Road,

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[5]CNR-IOM Dip. di Fisica, Univeristà di Roma Sapienza, P.le Aldo Moro 5, Roma, Italy

Abstract

FERMI is the Italian seeded Free Electron Laser (FEL) that works in a single pass - single bunch mode at 10 or 50 Hz, covering the spectral range from 100 to 4 nm. TeraFERMI is one of its six beamlines, that was built up in 2015. It is based on a Coherent Transition Radiation source which provides high intense THz electric fields in the multi MV/cm range. Such a THz radiation is delivered through the beamline in the laboratory, where several experimental configurations are available. The beamline allows addressing the THz nonlinear properties of materials by measuring the fluence-dependent transmission/reflection spectra or the pump-probe response, in both the single-colour (THz pump - THz probe) and the two-colours (THz pump - IR probe) configuration. Condensed matter is widely investigated at TeraFERMI: Two-dimensional materials, Dirac materials, semiconductors, oxides and superconductors are only some examples. Bio-chemical samples can also be studied at the beamline. Here, we will mainly focus on the case of topological insulators, which are very promising Dirac materials for addressing nonlinear optics. Indeed, thanks to their linear energy-momentum dispersion, the Dirac current depends on the sign of the momentum, instead of scaling with it. Such a singularity entails the intrinsic nonlinear behaviour of topological insulators, like saturable absorption, harmonic generation and nonlinear plasmonics. The latter case will be presented here on the Bi2Se3 topological insulator.

[1] Di Pietro P. et al., Synchrotron Radiation News, 30 - 4, 36-39 (2017).

[2] Di Pietro P. et al., Nature Nanotech., 8, 556–560 (2013).

[3] Di Pietro P. et al., Phys. Rev. Lett., 124, 226403 (2020).

Biography

Dr. Paola Di Pietro graduated in Physics in 2009 at Sapienza University of Rome, Italy. She then joined the group of Prof. Calvani and Prof. Lupi in the same University, as a PhD student. In 2012 she received her PhD degree and she moved to Elettra Synchrotron in Trieste (Italy) for a postdoctoral fellowship, supervised by Dr. Perucchi and related to the TeraFERMI project. Since 2018 she has been Beamline Scientist at TeraFERMI, where she carries out her research, mainly based on nonlinear properties of Topological Insulators.

An advanced RF timer of single electrons and photons

[1]Amur Margaryan, [1,9]Ani Aprahamian, [1]Vanik Kakoyan, [1]Simon Zhamkochyan, [1]Sergey Abrahamyan, [1]Hayk Elbakyan, [1]Arpine Piloyan, [1]Hasmik Rostomyan, [1]Anna Safaryan, [2]Bagrat Grigoryan, [3]John Annand, [3]Kenneth Livingston, [3]Rachel Montgomery, [4]Patrick Achenbach, [5]Josef Pochodzalla, [6]Dimiter L. Balabanski, [7]Satoshi N. Nakamura, [8]Viatcheslav Sharyy, [8]Dominique Yvon, [9]Maxime Brodeur, [9]Khachatur Manukyan

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[5]Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Mainz, Germany

[6]Extreme Light Infrastructure- Nuclear Physics (ELI-NP), Bucharest-Magurele, Romania

[7]Department of Physics, Graduate School of Science, the University of Tokyo, Tokyo, Japan

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Abstract

Recently an advanced RF timing technique has been developed at the A. Alikhanyan National Science Laboratory, AANL. It is based on a helical deflector, which performs circular, elliptical or spiral sweeps of keV electrons by means of the radio frequency electromagnetic fields lying in the range 500-1000 MHz. By converting the time of arrival of incident electrons to a hit position on a circle, ellipse or spiral, this device achieves extremely precise timing. Detection of the scanned electrons is implemented using a position sensitive detector based on microchannel plates and a delay line anode. Consequently, a photon sensor based on the RF timer, namely the RF Photo-Multiplier Tube (RFPMT) will be capable of detecting single photons with high time resolution and at MHz rates. Test studies of the demountable RFPMT with the RF synchronized femtosecond laser beam demonstrated 10 ps time resolution and 0.2 ps/hour stability. This 10 ps resolution is mainly due to the technical parameters of the prototype tube and RF deflector and could be reduced essentially by suitable optimization of those parameters. Operation of the RFPMT phase locked with the RF driven particle or laser beams results high resolution, high rate and highly stable timing systems for single

photons. With fast readout from a suitably pixelated anode, e.g., with Timepix3 anode and readout system, the RFPMT with a spiral scanning system can be operated dead time free with rates more than 100 MHz. Such a devise will be capable to detect thousands of photons with a few ps resolution, located in a time interval of a few 10 ns.

After further development, the RFPMT has potential applications in many fields of science and industry, which includes fundamental physics, quantum technologies, ultrafast science, high-energy particle and nuclear physics, accelerator physics, and biomedical imaging.

Biography

Amur Margaryan has completed his PhD at the Yerevan Physics Institute and continued studies in the field of experimental physics at Yerevan Physics Institute; Serpukhov proton accelerator, Serpukhov, Moscow region; JLab, Newport News, VA, USA; MAX-lab, Lund, Sweden; GRAAL experiment at European Synchrotron Radiation Facility in Grenoble, France. He is the Leading Scientific Researcher at A.I. Alikhanyan National Science Laboratory (Yerevan Physics Institute). He has more than 150 publications. He holds Soviet Union, US, and Armenian patents. His current research interest is in ultrafast photon detectors and optoelectronic devices.

To-tier resources: Light: Science & Applications, eLight and Light: Advanced Manufacturing

Dr. Chenzi Guo

Associate Professor of CIOMP, Chinese Academy of Sciences, China

Abstract

Light: Science & Applications (LSA, www.nature.com/lsa) is a Nature Academic journal, which publishes breakthrough researches from all aspects of optics and photonics. The latest impact factor of *LSA* is 20.256, ranking Top3 among all optics journals in the world for the past eight years.

Through the past 11 years, we have built up *LSA* as not only a top-tier resource for publications, but also a highly visible platform for scientific communication and collaboration, hosting events such as Light Conferences, Rising Stars of Light, Light Doctoral League, Seed of Light, Light People, etc.

Since 2021, we have launched two new journals - *eLight* (elight.springeropen.com) and *Light: Advanced Manufacturing* (light-am.com).

This talk will present the journals LSA, eLight and *Light: Advanced Manufacturing.*

Biography

Dr. Chenzi Guo is an editor of journal Light: Science & Applications, director of new journal eLight. She is a fellow of Youth Innovation Promotion Association of Chinese Academy of Sciences, and committee member of International Division of China Editology Society of Science Periodicals. She was awarded with 2022 Excellent Editors in China's Top-tier STM Journals, Outstanding Young Editors in China's STM Journals (First Prize), etc. She has co-authored the translated version of 1 book, and published in Light: Science & Applications, Nano Today, Science China Materials, Applied Optics, Materials Chemistry and Physics, ACS Sustainable Chemistry & Engineering, etc.

DAY 4 | Posters

Different Effects of Laser Removal of Coatings with Different Lasers Devices

Szymon Tofil

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Abstract

The paper presents a comparison of the effects of laser coating removal with the use of various laser devices. Laser cleaning of the surface layer for the aluminum alloy has been performed. Using different power densities of the laser beam emitted by the pulsed Nd: YAG laser for the tested material, the best treatment conditions were selected for their cleaning. Basic research included microscopic analysis of surface topography and analysis of chemical composition in micro-areas.

In order to clean the surface of contamination, laboratory comparative studies of the removal of coatings were carried out using the surface layer cleaning technique using two different pulsed lasers: TruMicro 5325c with UV radiation (343nm) and SPI G3.1 SP40P with near-infrared radiation.

Samples covered with various technological coatings were subjected to several variants of laser treatment (different laser power densities and different numbers of pulses). The paper presents selected results from laboratory tests.

A Hirox KH-8700 microscope with digital image analysis was used to observe the cleaned surface layer. The JEOL JSM-7100f device was also used, enabling scanning electron microscopy (SEM) with the possibility of analyzing the chemical composition of the surface layer before and after laser cleaning.

The effect of cleaning the surface of aluminum sheets covered with a technological coating using laser radiation is shown in Fig. 1. The cleaned surface does not have traces of laser melting, and only the effects of cleaning the coating are visible.

After cleaning, a highly clean surface was obtained. In the case of very thick coatings, the cleaning process should be repeated several times. In order to intensify the purification process, a laser with a higher average power can also be used.

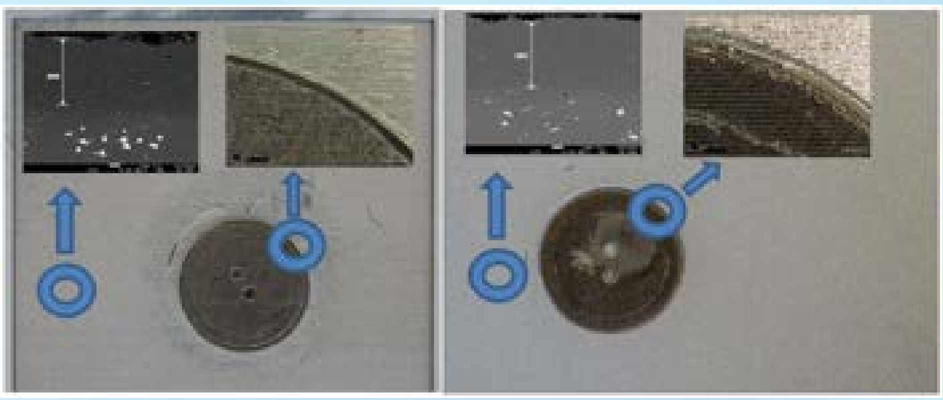

Figure 1: Figure illustrating the effects of laser removal of coatings using TruMicro 5325c (on the left) and SPI G3.1 SP40P (on the right) device.

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Biography

Szymon Tofil obtained a master's degree at the Faculty of Management and Computer Modelling at Kielce University of Technology in 2009. In the same year he started doctoral studies at the Faculty of Mechatronics and Mechanical Engineering, where he now works in the Department of Terotechnology and Industrial Laser Systems in Laser Processing Research Center. His research interests are connected with the issues of tribology and laser technology for modification of surface. In 2017-2020 he was the manager of the project entitled "Laser micromachining for inhomogeneous materials in adhesive joints technology in the systems such as plastic – metal, metal – ceramics and ceramics – plastics". Currently, he is the work manager of a consortium member in a project from the Path for Mazovia program in a consortium with the Warsaw University of Technology and LOT AMS company. He took part in projects from the LIDER VIII, IX and XI and other programs as one of the main contractors. In the project from the POIR program, he was the main contractor of works related to the development and preparation of an echogenic micro-probe for cryoelectrolysis made in laser technology.

Scientific interests: laser microtreatment, laser microwelding, laser microdrilling, laser ablation, adhesive joints, surface modyfications, laser cleaning.

Mechanically Assisted Laser Forming of New Kind Helical Metal Expansion Joints

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Mechanically Assisted Laser Forming of New Kind Helical Metal Expansion Joints

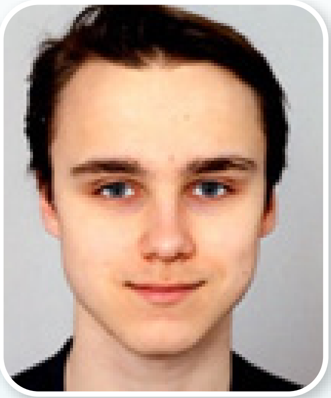
In every industrial pipelines installations we deal with variable parameters of the transmitted medium - temperature and pressure. As a result of changing working conditions, such an installation is exposed to damage related to a change in its geometry due to e.g. thermal expansion of the material. Therefore, there is a need to compensate for such an installation. In the case of high pressures and temperature changes, metal expansion joints are used (in the form of a bellows or a lens). Their design ensures compensation of axial, lateral and angular deformations. On the other hand, they do not compensate for the deformations resulting from the torques, which are the operation result of the equipment installed in the installation, e.g. valves, pumps, etc. The necessity to compensate this kind of deformations led to the idea of making helical expansion joints. The helical expansion joint has bellows on its circumference, but not in the form of classic rings, but in the form of a helix. The authors proposed the use of a hybrid mechanically assisted laser forming method to produce helical expansion joints. In this technique moving laser beam heats a given area of rotating pipe to a certain, preset temperature, which improves the plastic properties in this area. Then an axial force acts on the element simultaneously, which causes its upsetting in the plasticized zone (heated by the laser beam). The remaining part of the formed element, which has a lower temperature, does not deform. After process helical expansion joint is created. Authors presented ideas and assumptions of this technology and experimental results.

ACKNOWLEDGEMENTS: The research reported herein was supported by a grant from the National Centre for Research and Development. Program title: Lider XI, grant title: "Development of new type metal expansion joints and their manufacturing technology", contract number: LIDER/44/0164/L-11/19/NCBR/2020.

Biography

Dr. Piotr Kurp studied Mechanical Engineereing at Kielce University of Technology in Poland. He graduated as MS in 2004. From 2004 to 2007 he work in Pipeline Industry as pipelines designer. From 2007 he started PhD studies at the same University and joined the research group of Prof. Mucha. He received PhD degree in 2015 at the same institution. His specialization is generally laser treatment, mainly laser forming technologies. He participated in many Erasmus program and cooperate with Universities from Czech and Slovak Republik. He worked in many researched grants in Poland. He has published more than 60 research articles and he has 7 patents.

Nuclear Spin Control in GaAs Quantum Dots via Nuclear Quadrupole Resonance



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Abstract

Quantum dots (QDs) are an attractive system for quantum information storage and processing in a network. In a QD, an optically active electron is coupled to neighboring nuclei via the hyperfine interaction, which can be used to transfer electron spin states to this nuclear register with significantly longer coherence times, effectively realizing quantum memory. Such a memory requires accurate and efficient nuclear spin control, which is also vital to the suppression of unwanted noise due to the nuclear Overhauser field, a source of electron decoherence. Nuclear spins are traditionally controlled via nuclear magnetic resonance (NMR), a technique based on the coupling of a particle's spin to a radio-frequency magnetic field tuned to the frequency of a transition between Zeeman-split energy levels. While this method has been fruitful, it is constrained by the requirement of driving large currents in proximal coils. Our goal is to develop a new way of inducing nuclear spin transitions in GaAs QDs using nuclear quadrupole resonance (NQR), a method based on the quadrupolar coupling between the spin-3/2 nuclei and an oscillating electric field gradient (EFG). Two avenues can be pursued to this end: one uses strain waves, the other uses AC quadrupole antennas etched onto the GaAs device hosting the QDs. One advantage of the latter is that QDs are addressed locally; the present work focuses on this approach. We propose an ideal model and simulation results of Rabi frequencies for given antenna geometries and QD depth, and show that electron energy levels can be protected from undesired dipole fields. Further work will cover resonant circuit driving of the quadrupole antennas to reach EFGs sufficient for kHz to MHz Rabi frequencies on the nuclei. Our findings serve as a proof of concept for a promising alternative to NMR which could be implemented experimentally in the future.

Biography

Leonardo Cardinale is a second-year engineering student at Mines Paris – PSL. He was previously enrolled at the Lycée Louis-le-Grand in Paris to study Mathematics and Physics with Computer Science. He was a research intern in the Quantum Engineering group at the Department of Engineering Science at the University of Oxford, led by Professor Dorian Gangloff, where he worked on nuclear spin control in semiconductor quantum dots between October 2022 and February 2023.

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