NOP 2023

WORKSHOP ON NONLINEAR OPTICS AND PLASMONICS

September 6-8, 2023 | Lecce, Italy

TECHNICAL PROGRAM

ISTITUTO ITALIANO DI TECNOLOGIA

#NOP2023

https://nopconference.it

Contents

About

It is our great pleasure to welcome you to NOP2023, the first international workshop on Nonlinear Optics and Plasmonics, held in Lecce, Italy, on September 6-8, 2023. This conference gathers an excellent group of keynote speakers from different topics and covers both fundamental aspects and applications, featuring several internationally renowned invited speakers, as well as poster contributions. This conference is supported by the Italian Ministry of Foreign Affairs and International Cooperation (KR23GR01), the South Korean Ministry of Science and ICT, the National Research Foundation of Korea, Istituto Italiano di Tecnologia, and Pohang University of Science and Technology in South Korea.

Organizers

Dr. Cristian Ciracì, Istituto Italiano di Tecnologia, Italy.

Prof. Junsuk Rho, POSTECH, South Korea

Institutional supporters

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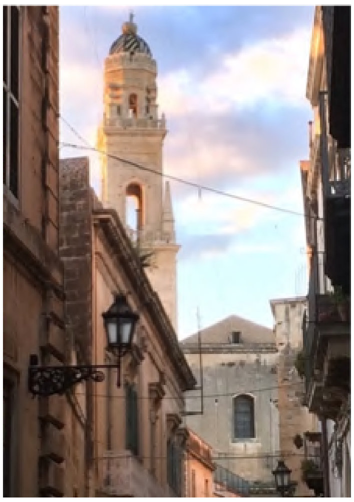
Venue

Lecce is a historic city in southern Italy, one of the most important cities of Apulia, featuring a rich collection of baroque architectural monuments and buildings. Lecce lies at the heel of Italy's boot between the Adriatic and Ionian Sea in the "Salento" area. The region offers kilometers of coastal landscape, blue sea-fringed bays, dunes and white sand beaches; it holds a rich and delicious gastronomic tradition and offers a lively and dynamic cultural scenario.

While in Lecce, enjoy a walk through the city's unique architecture. Some must-see places are: **Piazza Duomo**, **Basilica di Stanta Croce**, **Anfiteatro Romano**, **Ex Convitto Palmieri**, **Porta Napoli**, and **Porta San Biagio**

Lecce offers many food and drinks options within walking distance from the conference location. **Osteria da Angiulino** is a great and affordable option for a taste of Salento's traditional cuisine. Two of the best pizza places are **400 Gradi** and **La Gigante** where you can find "Naples" or "Salento" style pizza, respectively. **La Barca di Mario** is one of the best seafood option in the city center. Meat lovers cannot miss **La Locanda del Macellaio**, one of the best traditional "braceria" In Lecce, or **Il Carrettino** for the best burgers in town. If you are looking for a fancy dinner, **3 Rane Restaurant** is a little hidden gem. For late night drinks, check-out **Quanto Basta** and **Prohibition** for cocktails, or **Cantiere Hambirreria** for beers. This is not by all means an exhaustive list. Lecce is continuously evolving and new places to try out pop up every week. Do not be afraid to explore.

The conference will be held at **Officine Cantelmo**, a modern and vibrant conference center in the heart of Lecce's historic center, in **V.le M. de Pietro, 8a**.

The **poster sessions** will be held at **Ex-Convento degli Agostiniani**, situated at 350 m from the main conference location.

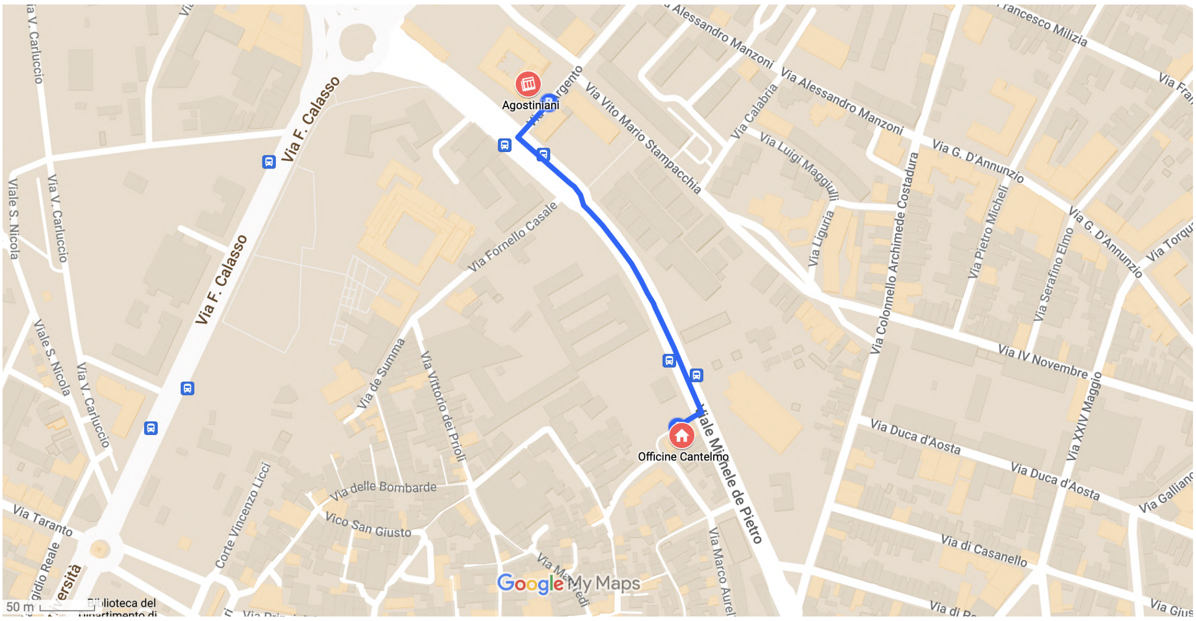
Conference dinner

The **conference dinner** will be held on Thursday night, September 7th, at **Palazzo Tamborrino Cezzi** situated **Via Guglielmo Paladini, 50**, within 15 minutes walk (through the city center) from the main conference location.

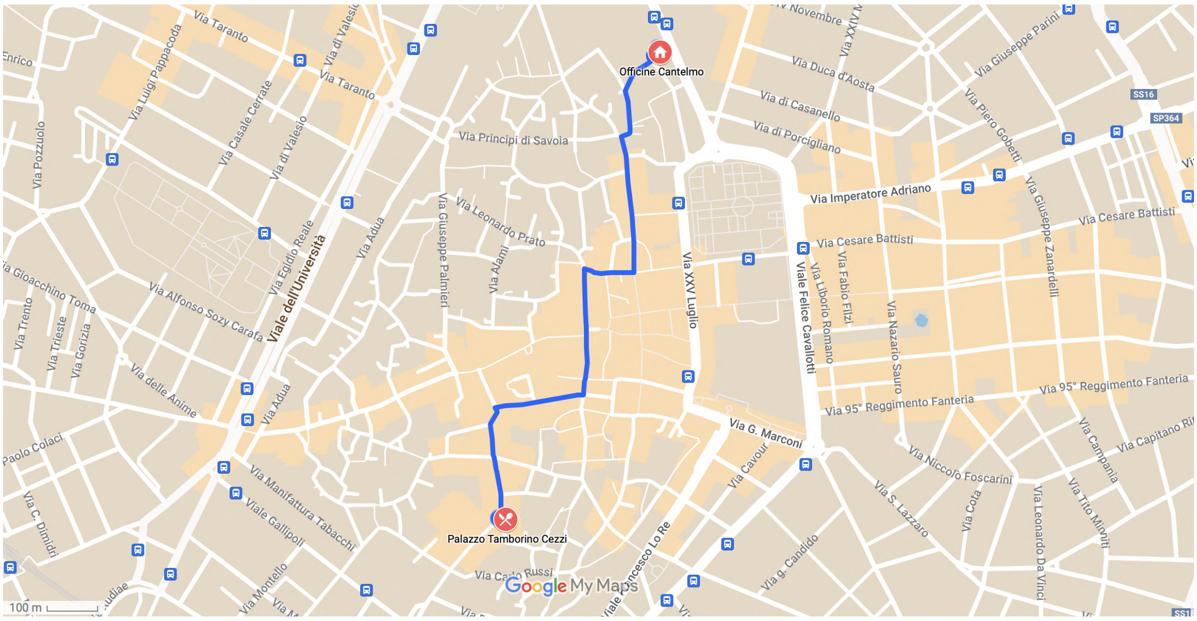
Palazzo Tamborrino Cezzi was erected in the mid-XVI century by Giacomo Mele, who came from an old family in the town. The house still has the renaissance rooms on the ground floor from this period. At the beginning of the seventeenth century it passed into the hands of the de' Giudici family, who had lived in the town for a long time and were of Genoan origin: Cola Maria de' Giudici embellished the house to such an extent that her contemporaries defined it as a "sumptuous palace". Following this the owners were briefly the Jesuits, the Staybano family, then the Capece family and from the beginning of the eighteenth century to the Unification of Italy, the Paladini family, a family of French origin, aristocrats, intellectuals and politicians. From the second half of the nineteenth century the mansion has belonged to the Tamborino family, who have been responsible for the structural and artistic changes that characterize its present appearance: the Cezzi family, who now own it, are descendants on the maternal side.The nineteenth century rebuilding of the house expressed the neoclassical taste of the period, which in the South of Italy was linked to the eclectic elegance of the Art Nouveau movement, and also to the Moorish and Oriental details which are still alive in this area.

Maps

From Officine Cantelmo to Ex-Convento degli Agostiniani



From Officine Cantelmo to Palazzo Tamborrino Cezzi

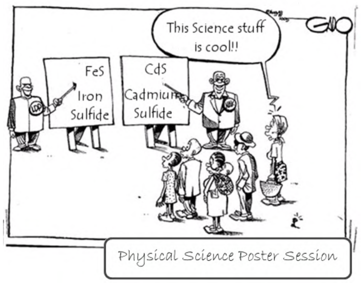


Awards

We are delighted to announce the support to young researchers of the De Gruyter, peer-reviewed, open access journal **Nanophotonics** (IF: 7.923). The journal covers recent international research results, specific developments in the field and novel applications. Every issue contains a balanced combination of invited review articles, regular articles, letters and opinionated reports. Nanophotonics focuses on the interaction of photons with nano-structures, such as carbon nano-tubes, nano metal particles, nano crystals, semiconductor nano dots, photonic crystals, tissue and DNA. The journal covers the latest developments for physicists, engineers and material scientists, working in fields related to plasmonics, metamaterials, and nanophotonics.

Nanophotonics is pleased to offer prizes to the **best posters** of NOP2023.

Instructions



The following information is provided to assist authors with the preparation of their presentation. You shall comply with these instructions and guidelines in order to make sure that your presentation will go smoothly. If you need any further information please write to cristian.ciraci@iit.it.

For oral presenters

You shall arrive at the room where your presentation is scheduled 15 minutes prior to the first presentation in that session and make yourself known to the session Chair. You shall stay for the whole session – for your paper and the papers of other speakers in that session – in order to enable the delegates who wish to speak with you at the end of the session to be able to find you easily. Your presentation shall last 20 minutes (40 minutes for the Keynotes) including questions. The Questions & Answers sessions should not exceed 5 minutes (10 minutes for the Keynotes). The Chair will time your presentation and provide you with a 2-minute warning. Please keep a strict eye on the time during your presentation.

For poster presenters

Your poster shall have a vertical or "portrait" orientation not exceeding the following dimensions: 841 × 1189 mm (A0 format). The poster shall be readable from a distance of 2-3 meters. Avoid fuzzy images; make sure all graphics are high-resolution and easily visible. Lists with your name and assigned poster ID will be available and displayed in the venue. The **poster sessions** will be held at **Ex-Convento degli Agostiniani**, situated at 350 m from the main conference location.

Program at a Glance

Wed, Sep 6		Thu, Sep 7		Fri, Sep 8	
10:00–10:50	**Welcome & registration**	09:00–10:40	**Session 4**	09:00–10:40	**Session 8**
10:50–11:00	**Opening**	10:40–11:10	**Coffee**	10:40–11:10	**Coffee**
11:00–12:40	**Session 1**	11:10–12:30	**Session 5**	11:10–12:10	**Session 9**
				12:10–12:30	**Awards & Closing**
12:40–14:00	**Lunch**	12:30–14:00	**Lunch**		
14:00–15:20	**Session 2**	14:00–15:20	**Session 6**		
15:20–15:50	**Coffee**	15:20–15:50	**Coffee**		
15:50–17:10	**Session 3**	15:50–17:10	**Session 7**		
17:20–18:40	**Posters 1** Agostiniani	17:20–18:40	**Posters 2** Agostiniani		
		20:00–22:30	**Dinner** Palazzo Tamborino Cezzi		

Wednesday, September 6th

10:00 - 10:50	**Welcome reception & Registration**	
10:50–11:00	**Opening statement**	
Session 1 – Chair: Cristian Ciracì		
11:00–11:40	**Philippe Lalanne** CNRS	Non-Hermitian resonators: the divergence, the Qs and Vs of their quasinormal modes
11:40–12:00	**Stéphane Kena-Cohen** Polytechnique Montreal	Nonlocal effects in ENZ antennas and new materials for second-order nonlinear optics
12:00–12:20	**Prineha Narang** University of California, Los Angeles	Nonlinear optics in topological quantum materials and axion electrodynamics
12:20–12:40	**Stefano Palomba** University of Sydney	On-chip SOI hybrid plasmonic nanofocusser
12:40–14:00	**Lunch**	
Session 2 – Chair: Michele Celebrano		
14:00–14:40	**Daniele Brida** University of Luxembourg	Ultrafast electron transport at the nanoscale
14:40–15:00	**Alexandre Bouhelier** CNRS	(On-line) Photonic memristors
15:00–15:20	**Yonatan Sivan** Ben-Gurion University	The nonlinear optical response and electron dynamics in ITO
15:20–15:50	**Coffee break**	
Session 3 – Chair: Prineha Narang		
15:50–16:10	**Martin, Schultze** Graz University of Technology	Strong light waves controlling charge and spin dynamics
16:10–16:30	**Giovanni Manfredi** CNRS	Driving orbital magnetism in metallic nanoparticles through plasmonic effects
16:30–16:50	**Luca Sortino** Ludwig-Maximilians-Universität München	Monolithic van der Waals metasurfaces
16:50–17:10	**Alexandre Baron** University of Bordeaux	Optical properties of self-assembled dense spherical clusters of plasmonic nanoparticles
17:20–18:40	**Poster Session 1** with Drinks & Food (Ex Convento degli Agostiniani)	

Thursday, September 7th

Session 4 – Chair: Junsuk Rho		
09:00–09:40	**Bumki Min** KAIST	Photonic Temporal and Time Crystals
09:40–10:00	**Andreas Tittl** Ludwig-Maximilians-Universität München	Photonic bound states in the continuum for spectrally selective nanophotonics
10:00–10:20	**Carlo Forestiere** University of Naples	Plasmonic and dielectric resonances of homogeneous objects: from quasistatic to the full-wave regime
10:20–10:40	**Marcus Ossiander** Graz University of Technology	Holes in silicon enable extreme ultraviolet metaoptics
10:40–11:10	**Coffee break**	
Session 5 – Chair: Yonatan Sivan		
11:10–11:30	**Angela Demetriadou** University of Birmingham	Persistent sub-radiant states with plasmonic nanocavities
11:30–11:50	**Antonio I. Fernandez-Dominguez** Universidad Autónoma de Madrid	Inverse design for quantum nanophotonics: qubit entanglement and Bell state preparation
11:50–12:10	**Martijn Wubs** Technical University of Denmark	Modeling collective light emission by a few solid-state quantum emitters
12:10–12:30	**Kyoung-Duck Park** POSTECH	Tip-enhanced cavity-spectroscopy to control excitonic behaviors at the nanoscale
12:30–14:00	**Lunch**	
Session 6 – Chair: Maria Cristina Larciprete		
14:00–14:40	**N. Asger Mortensen** University of Southern Denmark	Surface-response formalism for mesoscopic electrodynamics in plasmonic nanostructures
14:40–15:00	**Sang-Hyun Oh** University of Minnesota	(On-line) CMOS-based terahertz camera based on quantum-dot-enhanced upconversion
15:00–15:20	**Domenico de Ceglia** University of Brescia	Optical image differentiation with nonlinear flat optics
15:20–15:50	**Coffee break**	
Session 7 – Chair: Martin Schultze		
15:50–16:10	**Crina Cojocaru** Universitat Politècnica de Catalunya	Large nonlinear efficiency enhancement in the visible and UV ranges from plasmonic gold nanogratings

16:10–16:30	**Michael Scalora** US Army	Second and third harmonic generation from aluminum nanostructures
16:30–16:50	**Fan Yang** Sichuan University	A transformation optics approach to nonlinear and nonclassical plasmonics
16:50–17:10	**Michele Celebrano** Politecnico di Milano	Free-space interferometric routing of upconverted light by dielectric metasurfaces
17:20–18:40	**Poster Session 2** with Drinks & Food (Ex Convento degli Agostiniani)	
20:00–22:30	**Conference dinner** (Palazzo Tamborino Cezzi)	

Friday, September 8th

Session 8 – Chair: Michael Scalora		
09:00–09:40	**Natalia Litchinitser** Duke University	Beam shaping and frequency conversion in nonlinear all-dielectric metasurfaces
09:40–10:00	**Mihail Petrov** ITMO University	Optical torque induced by resonant harmonic generation in dielectric nanostructures
10:00–10:20	**Su-Hyun Gong** Korea University	2D semiconductor multilayers for ultra-thin nanophotonic platform
10:20–10:40	**Antoine Moreau** Université Clermont Auvergne	Making spatial dispersion useful
10:40–11:10	**Coffee break**	
Session 9 – Chair: Francesco Todisco		
11:10–11:30	**Joel Cox** University of Southern Denmark	Nonlinear nanoplasmonics with atomically thin materials
11:30–11:50	**Tommaso Venanzi** Istituto Italiano di Tecnologia	Free-electron infrared nonlinearities in heavily doped InGaAs nanoantennas
11:50–12:10	**Arseniy Kuznetsov** A*STAR	Passive and tunable flat optics with dielectric nanoantennas
12:10–12:30	**Awards and Closing Remarks**	

Detailed program

Wednesday, September 6th, 2023

Session 1 [11:00 – 12:40] Chair: Cristian Ciracì, Istituto Italiano di Tecnologia, Italy

11:00 **Non-Hermitian resonators: the divergence, the Qs and Vs of their quasinormal modes (Keynote)**

Tong Wu and Philippe Lalanne
Laboratoire Photonique, Numérique et Nanosciences, CNRS-IOGS-Université de Bordeaux, Bordeaux, France

Micro and nanoresonators enhance many light-matter-interaction processes and are used in various modern applications in photonics. They are open systems and their modes (often called quasinormal modes) are always leaky, have a finite lifetime and thus, are defined as source-free solutions of Maxwell equations at a complex frequency. The analysis of the non-Hermitian behavior of such resonator in their modal basis has 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.

11:40 **Nonlocal effects in ENZ antennas and new materials for second-order nonlinear optics**

Stéphane Kena-Cohen
Polytechnique Montréal, Montreal, Canada

In the first part of the talk, we will discuss the experimental realization of epsilon near-zero photonic gap antennas. We will show how the inclusion of nonlocal effects in the electronic response of the ENZ material is essential to improve the quantitative agreement between full wave simulations and experiment. In particular, nonlocal effects lead to sharp resonances in the field enhancement that are completely absent in the local model. These resonances, corresponding to points of vanishing group velocity, lead to nonlocal field enhancements 4-6x greater than in the local simulations. In the second part of the talk, we will talk about our efforts to develop a flexible platform for second-order optical nonlinearities based on thermally evaporated thin films of small molecules. Using the interplay between permanent dipole and hyperpolarizabilities, we obtain values of d31 and d33 ranging from 5-10 pm/V on arbitrary substrates.

12:00 **Nonlinear optics in topological quantum materials and axion electrodynamics**

Prineha Narang
University of California, Los Angeles, U.S.A

Parametric optical nonlinearities are critical to a wide spectrum of photonic technologies, from optical parametric oscillators to frequency combs to quantum information processing. Optical nonlinearities also serve as a powerful method for mapping material properties including the symmetries of electronic structure. Optical nonlinearities are generally very small in conventional materials as they depend on higher order effects. Parallel to these technical needs, the field of topological materials has seen the prediction and discovery of a large number of massless, three-dimensional linear dispersion systems known as Dirac and Weyl semimetals. It was soon realized that these materials may offer a rich new material phase space for extending the nonlinear effects of graphene including the role of topology and Berry connection. In this context, I will present our recent work on predicting the optoelectronic and nonlinear properties of Dirac and Weyl semimetals with an emphasis on figures of merit (FoMs) that we will evaluate for these new Weyl and Dirac semimetals that captures the confinement and nonlinearity, to describe the second and third order susceptibilities and electro-optic coefficients of the materials. Next, I will discuss our recent results on the multiphoton spectroscopy of a dynamical axion insulator. We demonstrate a two-step protocol for the unambiguous optical identification of the collective axion mode in such a system. Looking ahead, I will discuss how collective responses in topological quantum materials can be unambiguously identified in nonlinear electrodynamical probes.

12:20 **On-Chip SOI Hybrid Plasmonic Nanofocusser**

Stefano Palomba[1,2], Oliver Bickerton[1,2], Fernando Diaz[1], Thomas Kasebier[3], Stefanie Kroker[4], Ernst B. Kley[3], C. Martijn de Sterke[1,2], Alessandro Tuniz[1]
[1]*Institute of Photonics and Optical Science, School of Physics, The University of Sydney, Australia*; [2]The University of Sydney Nano Institute, The University of Sydney, Australia; [3]Institute of Applied Physics, Friedrich Schiller Universiat Jena, Germany; [4]Physikalisch-Technische Bundesanstalt, Germany

Silicon-on-insulator (SOI) chip-based hybrid-plasmonics combines advantages of all-integrated opto-electronic functionality and deep sub-wavelength optical confinement. However, the large difference in modal areas limits the coupling efficiency from conventional waveguides, in turn reducing the efficiency of light-matter interactions like nonlinear optical functions. Here we design, fabricate, and experimentally characterize an efficient on-chip SOI hybrid plasmonic nanofocussing waveguide, with a tip as small as 10 nm. The device operates by rotating the fundamental TE mode of a standard SOI waveguide to a TM mode of a hybrid plasmonic waveguide, and subsequently focussing it to the nanoscale. Since plasmonic nanofocussing cannot be demonstrated by far-field, linear experiments, we measure the second harmonic generation (SHG) at the tip. The wavelength-scale propagation distances make phase matching unnecessary – we can thus correlate the measured SHG to the degree of nanofocussing of the pump at the tip. The dramatic increase in SHG intensity for the sharpest tip indicates strong focusing; by comparing the slopes of the three curves, we can experimentally quantify the degree of maximum intensity enhancement – which is a factor of × 7.5 with respect to the strip case. Thanks to the excellent agreement between experiment and simulations we conclude through simulations that the pump light is focused down to a mode area of approximately 40 nm2, resulting in a 1200 intensity enhancement with respect to the silicon waveguide input. This represents the first TM plasmonic nano-focusser to monolithically interface with an industry-standard TE-input SOI waveguide. This work lays the foundations for efficient and compact on-chip, deep sub-wavelength sources and sensors, bridging integrated photonic circuits and metallic nanostructures – potentially down to single-atoms –enabling operation in nonlinear plasmonic and quantum regimes.

Session 2 [14:00 – 15:20] Chair: Michele Celebrano, Politecnico di Milano, Italy

14:00 **Ultrafast electron transport at the nanoscale (Keynote)**

Daniele Brida
Department of Physics and Materials Science, University of Luxembourg, Luxembourg

We demonstrated that single-cycle pulses of minute energy content may result in extremely nonlinear optical phenomena at the nanoscale by exploiting an electronic circuit with a few-nanometre gap between the tips of an optical antenna. The strong electrical bias provided by the field contained in ultrashort optical pulses was harnessed to drive tunnelling and ballistic acceleration of electrons to generate a current through the free-space gap with PHz bandwidth

14:40 **Photonic memristors**

Alexandre Bouhelier
Laboratoire Interdisciplinaire Carnot de Bourgogne CNRS UMR 6303, Université de Bourgogne, France

Electronic components integrating nanometer scale gap in their design were also crucial to the advent of novel form of computing. Memristors for instance are programmable voltage-dependant resistive devices deployed nowadays in cognitive hardware systems such as artificial neural networks, neuromorphic and reservoir computing. Memristive operation relies on resistance switching triggered by the electroformation and disruption of conductive path- ways within a nanometer-scale dielectric gap. Charge transport occurs by an electro-chemical reduction of metal ions aggregating to conductive filaments, or by migration of mobile defects, such as oxygen vacancies and nanoclusters. In this presentation, we introduce an atomic scale memristive device capable of emitting photons during resistive switching, superseding thus the need for an external optical source. Our device features the compact footprint of transistors and compatibility with the emerging memristive technology. We identified three mechanisms producing photons with vastly different properties. The crossover between emission regimes depends on the history of the memristor and its operating conductance. Our results suggests that this new generation of memristor pave the way for multidimensional neural networks using both electrons and photons as information carrier.

15:00 **The nonlinear optical response and electron dynamics in ITO**

Subhajit Sarkar, Ieng-Wai Un, Yonatan Sivan
Ben-Gurion University, Israel

Low electron density Drude (LEDD) materials such as transparent conducting oxides, plasmonic nitrides, became popular candidates for high-efficiency nonlinear optical applications, due to their unique near-infrared "epsilon near zero" point. Their nonlinearity is extremely large, reaching 100's of percent of the refractive index/permittivity. Peculiarly, despite the large body of related impressive experimental demonstrations, their theoretical modeling was mostly coarse, and has not yet conclusively elucidated the origins of the giant optical response. Here, we close this knowledge gap and provide a ""first principles"" model of the response of LEDD materials to ultrafast illumination. For concreteness, we focus on Indium Tin Oxide (ITO). Our model includes the Boltzmann equation (BE) complemented by a phonon dynamics equation, and an easy-to-use coarse-grained extended two temperature model (eTTM). We find the electron heat capacity of ITO to be smaller, but the electron-phonon energy transfer rate to be comparable to that in noble metals. This leads to stronger heating of the electrons, and to a faster cooling compared to noble metals [Fig. left(a)]. Surprisingly, the intense illumination and associated high electron temperature, may cause the effective chemical potential to become negative, thus, transiently converting the ITO into a semiconductor [Fig. left(b)]. We also find that the drastic increase of the real part of the permittivity shifts the resonance from the pump such that the absorptivity drops rapidly with increased illumination intensity [Fig. right(a)]. Consequently, the phonon temperature increases sub-linearly with the pump peak-intensity, reaching the melting point of at 500 GW/cm2 [Fig. right(b)]. This explains, for the first time to our knowledge, the experimental observation of the high damage threshold of ITO and shows that the ITO nonlinearity is not saturable, but rather thermal as for noble metals.

Session 3 [15:50 – 17:10] Chair: Prineha Narang, University of California Los Angeles, USA

15:50 **Strong light waves controlling charge and spin dynamics**

Martin Schultze
Graz University of Technology, Austria

I will discuss a set of experiments demonstrating the capability of single cycle optical fields to deliberately drive currents and alter the magnetization state of solid bulk materials and nano-heterostructures.

16:10 **Driving orbital magnetism in metallic nanoparticles through plasmonic effects**

Giovanni Manfredi[1], J. Hurst[1], P.-A. Hervieux[1], R. Sinha-Roy[2], P. Oppeneer[3]
[1]*Université de Strasbourg, CNRS, Franc;* [2]*Aix-Marseille Université, France;* [3]*Uppsala University, Sweden*

The topic of this contribution is the generation of large magnetic fields in non-magnetic materials through polarized laser fields. Transfer of angular momentum from helicity-controlled laser fields to a nonmagnetic electronic system can lead to the creation of magnetization. The underlying mechanism in metallic nanoparticles has been identified as the inverse Faraday effect (IFE), whereby a quasi-static magnetic field is generated by an external oscillating lase field and is proportional to the laser intensity. Here, we show that the IFE can be strongly amplified in small gold nanoparticles thanks to plasmonic effects. If the laser frequency matches the plasma frequency of the conduction electrons in the metal (surface plasmon resonance), a strong oscillating electric field is excited in the nanoparticle. Through the IFE, this internal self-consistent field generates a sizeable magnetization, of the order of tens of Bohr magnetons. The primary contribution to the magnetization comes from surface currents generated by the self-consistent field. The effect is maximum for circularly polarized laser fields and disappears for linearly polarized fields. This plasmonic IFE is studied here using both a simplified quantum hydrodynamic model and fully quantum simulations based on the time-dependent density functional theory. This is an important step in the ultrafast manipulation of magnetic effects in nano-objects via electromagnetic waves, which may find applications for the storage, writing, and reading of information based on optical means.

16:30 **Monolithic van der Waals metasurfaces**

Luca Sortino[1], Stefan A. Maier[1,2,3], Andreas Tittl[1]
[1]*Chair in Hybrid Nanosystems, Faculty of Physics, Ludwig-Maximilians-Universität München, Munich, Germany;* [2]*School of Physics and Astronomy, Monash University, Clayton, Australia;* [3]*Department of Physics, Imperial College London, London, United Kingdom*

Van der Waals (vdW) materials, such as hexagonal boron nitride (hBN) and Transition Metal Dichalcogenides (TMDCs) semiconductors, are layered crystals with exceptional properties to investigate light-matter interaction at the nanoscale. In their atomically thin form they exhibit appealing features, such as tightly bound excitons and optically addressable defects, while in their bulk form they exhibit giant optical anisotropy and large refractive index values (n>4), larger than common semiconductor materials, making them a favorable candidate for the realization of low-loss optical resonances in all-dielectric nanophotonic structures. In our work, we leverage the physics of quasi bound states in the continuum (qBIC) to achieve high quality (Q) factors optical resonances in symmetry-broken dielectric metasurfaces. Notably, our approach is monolithic, meaning that it is exclusively composed of vdW materials, and allows to realize optical resonances with Q factors above 102 through a two-step fabrication process. We demonstrate spectral tuning over the whole visible spectrum in hBN qBIC metasurfaces and enhanced light-matter coupling with intrinsic spin defects in hBN. In the latter, we observe a remarkable 25-fold enhancement of the photoluminescence intensity and spectral narrowing of the defect emission, with linewidth below 4 nm full width at half-maximum. Moreover, our platform opens exciting opportunities for strong light-matter coupling, demonstrated in the clear anti-crossing behavior between qBIC resonances and intrinsic excitons in monolithic TMDC WS2 metasurfaces, exhibiting Rabi splitting up to 116 meV under ambient conditions and independent on the material's intrinsic losses. Our results demonstrate how merging qBIC photonic metasurfaces with vdW materials paves the way to the realization of novel hybrid nanophotonic platforms and room temperature polaritonic devices.

16:50 **Optical properties of self-assembled dense spherical clusters of plasmonic nanoparticles**

Alexandre Baron[1,2], Ranjeet Dwivedi[3], Ashod Aradian[1], Virginie Ponsinet[1], and Kevin Vynck[4]
[1]*Univ. Bordeaux, CNRS, CRPP, UMR 5031, France;* [2]*Institut Universitaire de France, France;*

[3]*ENSEMBLE3, Centre of Escellence, Wolczynska Poland;* [4]*Univ. Claude Bernard Lyon 1, CNRS, iLM, France*
Densely-packed spherical colloidal clusters of metallic inclusions, also known as plasmonic balls, have garnered a lot of interest recently, owing to their remarkable scattering behaviors and potential applications. Using an emulsion route, we have been able to produce dense spherical balls and show that they act as resonant Huygens scatterers, where the intereferences of mutlipoles of even and odd parity lead to coherent forward scattering. We shall review recent designs and realizations of such Huygens scatterers using self-assembly. The interaction of light with inhomogenous spheres such as these clusters is notoriously difficult to describe theoretically. We have studied numerically the electromagnetic behavior of plasmonic balls composed of many particles using high-precision T-matrix calculations. We have shown that it is empirically possible to find an equivalent effective medium description for the clusters, taking into account spatial dispersion. We find that the average scattered field as well as the average inner field of a spherical cluster as computed from the T-matrix approach can be equivalently obtained by an extended Mie theory where three effective parameters are used to describe the inner effective medium, namely an electric permittivity $\varepsilon_{\mathrm{eff}}$, a magnetic permeability μ_{eff}, and a longitudinal wavevector k_{L}. The latter two account for strong interparticle couplings entailing spatial dispersion effects , which cannot be neglected in dense systems near the plasmonic resonance. Our study therefore shows that (within the range of studied sizes), it is possible to treat a cluster of plasmonic particles as a sphere made of a spatially-dispersive effective equivalent medium, even for high concentration in particles. This work broadens the range of effective parameters that can be obtained and exploited in the design of meta-atoms and metamaterials.

Poster Session 1 [17:20 – 18:40]

1. **Second-harmonic generation in monocrystalline gold nanostructures: implications of anisotropic second-order susceptibility**
   Sergejs Boroviks, Olivier J.F. Martin
2. **Plasmonic-like hot-electron nonlinear photoluminescence from patterned ITO thin films**
   F. Dell'Ova, G. Colas-des-Francs, E. Dujardin, Alexandre Bouhelier
3. **Quasi-periodic snap-buckling mechanisms in polymeric nano-bubbles: Toward highly efficient radio-acoustic energy transducers**
   Salvatore Buonocore, Aliaksandr Hubarevich, Francesco De Angelis
4. **Ab initio study of a metal-molecule system for polaritonic chemistry applications**
   Lucia Cascino, S. Corni and S. D'Agostino
5. **Mid-infrared Berreman modes tuning in GaN/AlGaN visible multilayer cavities on Sapphire for broadband nonlinear frequency conversion**
   Marco Centini, Alessandro Bile, Alessandro Belardini, Daniele Ceneda, Adriana Passaseo, David Maria Tobaldi, Concita Sibilia, and Maria Cristina Larciprete
6. **Electro-optic imaging of electric fields in irradiated CdTe detectors**
   Adriano Cola, Lorenzo Dominici, Antonio Valletta
7. **Quantum dynamics and entanglement with multiple plasmonic modes**
   Angus Crookes, Ben Yuen, Angela Demetriadou
8. **K-space hyperspectral imaging of microcavities and metasurfaces by an ultrastable common-path interferometer**
   Armando Genco, Cristina Cruciano, Benedetto Ardini, Matteo Corti, Kirsty McGhee, Luca Sortino, Ludwig Hüttenhofer, Tersilla Virgili, David G. Lidzey, Stefan A. Maier, Andrea Bassi, Gianluca Valentini, Giulio Cerullo, Cristian Manzoni
9. **Anomalous thermally activated delayed fluorescence (TADF) response for a phenothiazine**

derivative: a TD-DFT study
L. Cascino, A. Maggiore, I. Rivalta, G. P. Suranna, R. Grisorio, D. Conelli , V. Maiorano, Stefania D'Agostino

10. **Nonlinear and linear spatiotemporal reshaping of polariton fluids**
Lorenzo Dominici, Nina Voronova, Amir Rahmani, Antonio Gianfrate, Daniele Sanvitto, Michał Matuszewski, Marzena Szymańska, Ricardo Carretero, Fabrice Laussy

11. **Advanced electromagnetism using FEniCSx**
Stefano Greco, Michele Castriotta, Cristian Ciracì

12. **Microscopic theory for active plasmonics in THz-pumped metal nanoparticles**
Jonas Grumm, Robert Salzwedel and Andreas Knorr

13. **Ultrafast Thermo-Optical Response of Drude Metals**
Na'ama Harcavi, Peleg Fishgrund, Yonatan Sivan

14. **Theory of free-electron third order nonlinearities in heavily doped InGaAs nanoantennas**
Huatian Hu, F. De Luca, T. Venanzi, M. Ortolani, V. Giliberti, A. Rossetti, T. Deckert, D. Brida, M. Pea, A. Bousseksou, L. Lucia, R. Colombelli, and C. Ciracì

15. **Squeezing free space with nonlocal metasurfaces towards ultrathin imaging systems**
Imon Kalyan, Nir Shitrit

Thursday, September 7^{th}, 2023

Session 4 [09:00 – 10:40] Chair: Junsuk Rho, POSTECH, South Korea

09:00 **Photonic temporal and time crystals (Keynote)**

Bumki Min
Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea

A photonic temporal crystal is characterized by its optical properties being periodically modulated over time, rendering it a temporal counterpart to spatially periodic photonic crystals. As early as 1966, the electromagnetic wave dynamics in a space-time periodic medium were theoretically explored, with the aim to describe time-growing instabilities in distributed parametric media. However, only a handful of theoretical studies followed this initial investigation, until an experiment utilizing a dynamic transmission line confirmed the existence of a shallow, yet genuine, momentum gap. Following this pioneering work, the popularity of time-varying photonics surged recently, with a primary focus on the conceptual extension of photonic spatial crystals and metamaterials into the space-time domain. More specifically, the enhanced dispersion and band structure engineering capabilities, facilitated by the additional temporal degree of freedom, have been the subject of extensive research. A multitude of intriguing phenomena such as colossal broadband nonreciprocity, efficient one-way amplification, parametric oscillation, pulse compression, and harmonic generation, have been theoretically or numerically considered for potential applications. It was only recently, however, that Floquet systems analysis was employed to shed more light on photonic temporal crystals. The momentum gap was confirmed to be the broken phase of parity-time (PT) symmetry along the wavenumber axis, while its edges were identified as non-Hermitian degeneracies, or exceptional points. In this talk, I will discuss non-Hermitian band structures, local density of states, and light-matter interactions in photonic temporal crystals. Moreover, I will delve into how nonlinearity can lead to discrete time translational symmetry breaking and result in the so-called time-crystalline behaviour within photonic temporal crystals.

09:40 **Photonic bound states in the continuum for spectrally selective nanophotonics**

Andreas Tittl
Chair in Hybrid Nanosystems and Center for NanoScience, Faculty of Physics, Ludwig-Maximilians-Universität München, Germany

Photonic bound states in the continuum (BICs) have enabled far-reaching nanophotonic applications in high-harmonic generation, biospectroscopy, and lasing. BIC-based metasurfaces with tailored structural asymmetry have empowered these advances, but still face constraints related to large metasurface footprints, the need for complex polarization states, or fabrication limits requiring constant resonator heights throughout the structure. In this talk, I will present several recent concepts for obtaining additional photonic functionalities in such systems, including the arrangement of BIC-based unit cells in semi-infinite radial configurations for polarization invariance and reduced footprints as well as height-driven BICs leveraging resonators with different thicknesses as an additional degree of freedom for resonance engineering.

10:00 **Plasmonic and dielectric resonances of homogeneous objects: from quasistatic to the full-wave regime**

Carlo Forestiere and Giovanni Miano
Università degli Studi di Napoli Federico II, Napoli, Italy

The electromagnetic scattering resonances of a non-magnetic object much smaller than the incident wavelength in vacuum can be either described by the electroquasistatic approximation of the Maxwell's equations if its permittivity is negative, or by the magnetoquasistatic approximation if its permittivity

is positive and sufficiently high. Nevertheless, these two approximations fail to correctly account for the frequency shift and the radiative broadening of the resonances when the size of the object becomes comparable to the wavelength of operation. Starting from the full-wave eigenvalue problem, we introduce radiation corrections to the electroquasistatic and magnetoquasistatic resonances of arbitrarily-shaped objects are derived. Closed-form expressions of the frequency-shift and the radiative Q-factor of both plasmonic and dielectric modes of small objects are introduced.

10:20 **Holes in Silicon enable extreme ultraviolet metaoptics**

Marcus Ossiander[1,2], Hana K. Hampel[1], Maryna L. Meretska[2], Soon Wei D. Lim[2], Nico Knefz1, Thomas Jauk[1], Federico Capasso[2], Martin Schultze[1]

[1]*Institute of Experimental Physics, Graz University of Technology, Graz, Austria;* [2]*John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, USA*

We realize the first metalens operating in the extreme ultraviolet spectrum (50 nm wavelength) and demonstrate its performance using high-harmonic-generation.

Session 5 [11:10 – 12:30] Chair: Yonatan Sivan, Ben-Gurion University, Israel

11:10 **Persistent sub-radiant states with plasmonic nanocavities**

Angela Demetriadou, Kalun Bedingfield, Angus Crookes, Ben Yuen

School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom

Plasmonic nanocavities have gaps of just 1-2nm and allow for light-matter strong coupling between molecular emitters and plasmons to be realized at room temperature. The continious energy exchange between the emitters and the plasmon leads to Rabi oscillations that dissipate quickly due to the high losses of the plasmonic system. Here, we show that when two (or more) emitters are placed in a plasmonic nanocavity, one can generate persistent sub-radiant states between the emitters that live up to 100 times longer than the Rabi oscillations.

11:30 **Inverse design for quantum nanophotonics: qubit entanglement and Bell state preparation**

Antonio I. Fernandez-Dominguez

Departamento de Física Teórica de la Materia Condensada and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, Spain

In this talk, I will explore the generation of entanglement between two quantum emitters through the inverse-design engineering of their photonic environment. By means of a topology-optimization approach, I will show how dielectric cloaks can be generated that operate at different inter-emitter distances and incoherent pumping strengths. I will show that the structures obtained yield steady-state concurrence values much larger than those attainable in free space, approaching the limit of maximum-entangled-mixed-states. Next, I will show how the emitter pair can be prepared, with fidelities approaching unity, into the symmetric and anti-symmetric Bell states under coherent pumping, again, through the inverse-design of the dielectric medium hosting them.

11:50 **Modeling collective light emission by a few solid-state quantum emitters**

Martijn Wubs[1,2], Mads A. Jørgensen[1], Devashish Pandey[1], Nicolas Stenger[1,2], Sanshui Xiao[1,2]

[1]*Dept. of Electrical and Photonics Engineering, Technical University of Denmark, Denmark;* [2]*NanoPhoton – Center for Nanophotonics, Technical University of Denmark, Denmark*

We present recent results on collective emission (superradiance and subradiance) by quantum emitters. The first part is about the effect of making the rotating-wave approximation. This is a very common approximation and already Dicke made it in his seminal work on superradiance. While single-emitter spontaneous emission rates are the same whether the approximation is made, this does not hold for collective emission rates: for two identical emitters, the sub- and superradiance decay rate are still the same whether ones makes the approximation or not, but for two slightly detuned emitters or for three or more identical emitters, the collective rates that one finds will generally be different, and the difference can be considerable. In the second part we present results on solid-state quantum emitters in photonic nanostructures. These emitters are open quantum systems in a double sense, as they typically couple both to the electromagnetic field and to phonons. In state of the art experiments it has become possible to engineer collective light emission despite the presence of phonons. We present and compare two methods to calculate superradiant spectra that take both Markovian and non-Markovian effects of phonons into account.

12:10 **Tip-enhanced cavity-spectroscopy to control excitonic behaviors at the nanoscale**
Kyoung-Duck Park
Department of Physics, Pohang University of Science and Technology (POSTECH), Pohang, Republic of Korea
The tunability of the bandgap, radiative emission, and energy transfer in transition metal dichalcogenide (TMD) monolayers provides a new class of functions for a wide range of ultrathin photonic devices. Additionally, understanding and controlling the nanoscale transport of excitonic quasiparticles, such as excitons and trions, in atomically thin 2D semiconductors are crucial to produce highly efficient nano-excitonic devices. In this work, we present a dynamic nano-mechanical strain-engineering of naturally-formed wrinkles in a WSe2 monolayer, with real-time investigation of nano-spectroscopic properties using tip-enhanced cavity-spectroscopy. We reveal the modified nano-excitonic properties by the induced tensile strain at the wrinkle apex, exhibiting the exciton funneling phenomenon. In addition, we demonstrate a nanogap device to selectively confine excitons or trions of 2D TMDs at the nanoscale, facilitated by the drift-dominant exciton funneling into the strain-induced local spot. Furthermore, we present a method for the all-optical control of the exciton-to-trion conversion process and its spatial distributions in a MoS2 monolayer. We exploit propagating surface plasmon polaritons (SPPs) to localize hot electrons in a 2D TMD transferred on a metal–insulator–metal (MIM) waveguide. Our work provides a new strategy for robust, tunable, and ultracompact nano-excitonic devices using atomically thin semiconductors.

Session 6 [14:00 – 15:20] Chair: Maria Cristina Larciprete, Sapienza, University of Rome, Italy

14:00 **Surface-response formalism for mesoscopic electrodynamics in plasmonic nanostructures (Keynote)**
N. Asger Mortensen
Center for Polariton-driven Light–Matter Interactions, University of Southern Denmark, Denmark; Danish Institute for Advanced Study, University of Southern Denmark, Denmark
The electrodynamics of matter and optical phenomena are commonly explored within the framework of classical electrodynamics and semiclassical models for the interactions of light with matter. Materials are commonly assumed homogeneous, and light-matter interactions are treated in an intuitive local manner. The plasmonic response of metal nanostructures is one such example, where the understanding of mesoscopic electrodynamics at metal surfaces is, however, becoming increasingly important for both fundamental developments in quantum plasmonics and potential applications in emerging light-based quantum technologies. The addition of surface-response formalism to classical electrodynamics is a way to represent quantum aspects and microscopic details of the electrodynamics at metal surfaces. The talk will discuss recent examples of nonlocal effects that emerge in surface-plasmonic systems, including metal surfaces, 2D materials, and combinations thereof.

14:40 **CMOS-based terahertz camera based on quantum-dot-enhanced upconversion**
Sang-Hyun Oh
Department of Electrical and Computer Engineering, University of Minnesota, Minneapolis, USA

This work focuses on the developed of new terahertz cameras based on CMOS image sensors. Detection of terahertz (THz) radiation has numerous potential applications, but currently faced with limitations in detector performance such as sensitivity, speed, bandwidth, and operating temperature. Most of THz detectors also lack the ability to determine THz polarization states. However, the recent discovery of THz-driven luminescence in quantum dots offers a viable detection mechanism through field-driven inter-quantum-dot charge transfer. We introduce a THz camera and polarimeter that functions at room temperature, utilizing a complementary metal-oxide-semiconductor and a quantum-dot-enhanced THz-to-visible upconversion mechanism. With optimized luminophore geometries and fabrication designs, this nanoslit-based sensor achieves broadband and fast responses, and is capable of detecting THz pulses with peak fields as low as 10 kV/cm. Furthermore, we present a new coaxial nanoaperture-type device that possesses a hitherto unexplored ability to record the THz polarization state and field strength simultaneously, with comparable sensitivity.

15:00 **Optical image differentiation with nonlinear flat optics**

Domenico de Ceglia[1,2], Andrea Alù[3,4], Dragomir N. Neshev[5], Costantino De Angelis[1,2]
[1]*Department of Information Engineering, University of Brescia, Italy;* [2]*CNR-INO (National Institute of Optics), Italy;* [3]*Photonics Initiative, Advanced Science Research Center, City University of New York, USA;* [4]*Physics Program, Graduate Center, City University of New York, USA;* [5]*The Australian National University, Canberra, Australia*

We show that flat-optics elements with nonlinear response can be used to engineer Volterra kernels capable of real-time image processing. To illustrate this concept, we present an edge detection system that exploits the nonlinear response of a simple flat optics element. This approach offers several advantages compared to linear flat-optics-based edge detection and differentiation, including broad operation across different frequencies due to its non-resonant mechanism, significantly enhanced contrast, and improved performance in the presence of noise. Our findings suggest that the implementation of Volterra kernels in nonlinear flat optics opens up new possibilities for analog processing and computing using nonlocal nonlinear metasurfaces.

Session 7 [15:50 – 17:10] Chair: Martin Schultze, Graz University of Technology, Austria

15:50 **Large nonlinear efficiency enhancement in the visible and UV ranges from plasmonic gold nanogratings**

Crina Cojocaru[1], S. Mukhopadhyay[1], M. A. Vincenti[2], L. Rodriguez-Sune, K. Hallman[3], M. Scalora[4] and J. Trull[1]
[1]*Department of Physics, Universitat Politècnica de Catalunya, Terrassa (Barcelona), Spain;* [2]*Department of Information Engineering – University of Brescia, Italy;* [3]*PeopleTec, Inc. 4901-I Corporate Dr., Huntsville, AL 35805, USA;* [4]*Aviation and Missile Center, US Army CCDC, Redstone Arsenal, AL 35898-5000, USA*

We report a combined experimental/theoretical investigation on second and third harmonic generation from a plasmonic gold nanograting, resonant in the near IR. The intense field localization leads to more than three orders of magnitude enhancement in nonlinear optical processes, compared to flat gold nanolayer. The qualitative and quantitative spectral and angular dependence of the harmonics were experimentally recorded and validated within the framework of our microscopic, hydrodynamic model for linear and nonlinear material dispersion.

16:10 **Second and third harmonic generation from aluminum nanostructures**

Michael Scalora[1], K. Hallman[2], S. Mukhopadhyay[3], R. Vilaseca[3], C. Cojocaru[3], J. Trull[3], D. de Ceglia[4], M. A. Vincenti[4]
[1]*Aviation and Missile Center, US Army, Redstone Arsenal, AL 35898-5000, USA;* [2]*PeopleTec, Inc. 4901-I Corporate Dr., Huntsville, AL 35805, USA;* [3]*Department of Physics, Universitat Politècnica*

de Catalunya, Terrassa (Barcelona), Spain; [4]Department of Information Engineering – University of Brescia, Italy

Plasmonics is concerned with the interaction of light with free charges on conductive surfaces. Historically, gold and silver have been the preferred choices because of low losses in the visible and near-IR portions of the spectrum. Here we report theoretical predictions and experimental observations of second and third harmonic generation from aluminum nanolayer so that we extract the intrinsic linear and nonlinear optical properties and establish baseline behavior, and then apply them to different grating structures in the hope of enhancing those basic properties. The push toward the ultraviolet range and beyond calls for additional studies of Au and Ag and alternative materials to determine their viability, a search that naturally highlights Al [1]. In some studies Al has been reported to outperform silver in the visible range due to its superior surface and interface properties [2]. However, most studies have been conducted over a limited wavelength range [3] with simple effective models. Unlike most noble metals, which display Lorentz-like behavior (interband transitions) in the UV range, Al is characterized by an absorption resonance near 850nm, which uncharacteristically splits the plasmonic range, and sets its linear and nonlinear optical properties apart. We set out to study Al with the aid of a hydrodynamic-Maxwell model that accounts for linear and nonlinear material dispersions, surface and volume nonlinear sources to study harmonic generation first from a simple Al layer a few tens of nanometers in thickness, and then from gratings and nanoantenna arrays that may display a combination of plasmonic and longitudinal Fabry-Perot resonances that localize the field inside a small volume. Our preliminary results suggest that bound charges play an outsized role in SHG, suggesting that predictions solely based on the free electron model may not adequately be used for prediction purposes, and that the absorption resonance play a pivotal role in THG.

16:30 **A transformation optics approach to nonlinear and nonclassical plasmonics**

Fan Yang
College of Physics, Key Laboratory of High Energy Density Physics and Technology of the Ministry of Education, Sichuan University, China

The plasmonic effects in the nanostructure provide a strong light-matter interaction between the structure and light, resulting in a giant nonlinear and nonclassical optical response. However, the analytical study of nonlinear and nonclassical effects in plasmonic structures is limited to basic geometries, such as flat surfaces, cylinders, or spheres. For a more complex geometry, an analytical solution becomes unobtainable. Fortunately, transformation optics, as a powerful analytical tool, has been employed in nonlinear and nonclassical plasmonics to solve this dilemma. For nonlinear plasmonics, second and third-harmonic generations from a nanowire dimer and a singular metasurface have been analytically studied. We found that the direct and the cascaded THG possess different size-dependence that can be used for experimental characterization of a nonlinear signal. Moreover, the SHG from a singular metasurface with a hidden dimension weakly depends on the pump field's incident angle, making it a perfect candidate as an all-angle harmonic-generation device. Regarding nonclassical plasmonics, nonlocal and electron spill-out effects have been thoroughly explored in the singular plasmonic system featured with a sharp point or a sub-nanometer metallic gap. A direct analytical approach to singular structures is complicated, but an indirect transformation optics approach that converts a complex nanostructure into a flat layered geometry becomes favorable. Obtaining the mapping rule of nonlocal parameter or Feibelman d parameter between the physical space and transformed virtual space, the complex nonclassical response of a singular nanostructure is significantly simplified.

16:50 **Free-space interferometric routing of upconverted light by dielectric metasurfaces**

A. Di Francescantonio[1], A. Zilli[1], D. Rocco[2], F. Conti[1], L. Coudrat[3], M. Morassi[4], A. Lemaître[4], P. Biagioni[1], L. Duò[1], C. De Angelis[2], G. Leo[3], M. Finazzi[1], Michele Celebrano[1]

[1] *Physics Department, Politecnico di Milano, Italy;* [2] *Department of Information Engineering, University of Brescia, Italy;* [3] *Université de Paris, CNRS, Laboratoire Matériaux et Phénomènes Quantiques, France;* [4] *Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Saclay, France*
We recently investigated frequency upconversion in both plasmonic and dielectric nanoantennas. Thanks to the adopted dual-beam pump scheme, where an ultrashort pulse at telecom wavelength impinges on the sample along with its frequency-doubled replica, Third Harmonic Generation (THG) and Sum Frequency Generation (SFG) processes are degenerate in energy. Although this should yield interference between the two processes, in all-delectric AlGaAs nanocylinders the symmetry of the system fully suppresses the interference term. Here, by applying the above dual-beam pump scheme to a periodic AlGaAs metasurfaces, we attain all-optical routing of the upconverted telecom photons in the visible range. This is attained by tuning the metasurface diffraction with respect to the meta-atom nonlinear emission in the Fourier plane, hence breaking the detection symmetry. Using the relative phase between the pump pulses as a tuning knob, we routed the upconverted radiation among different metasurface diffraction orders with an efficiency up to 90%. In particular, this is enabled by the maximization of constructive/destructive interference between SFG and THG in specific k-space directions. We also demonstrate that the polarization state of both pump and emission allows to reconfigure the routing between different sets of diffraction orders. The proposed approach can be envisioned as an all-optical method to route upconverted telecom photons into various detection channels. The combination of the interferometric and nonlinear character of the emitted light could be also extremely appealing for applications to nonlinear sensing.

Poster Session 2 [17:20 – 18:40]

16. **Crossover from non-thermal to thermal photoluminescence from metals excited by ultrashort light pulses**
Imon Kalyan, Ieng Wai Un, Kaiqiang Lin, John M. Lupton, Sebastian Bange, Yonatan Sivan
17. **Thermoplasmonic optical fiber probe: An experimental and computational analysis of the heating characteristics for neuroscience applications**
Muhammad Fayyaz Kashif, Di Zheng, Linda Piscopo, Cristian Ciracì ,Massimo de Vittorio, Ferruccio Pisanello
18. **LNOI reconfigurable optical phased arrays for on-chip wireless switches**
Muhammad Khalid, G. Bellanca, Y. Pezhman, V. Petruzzelli, G. Calò
19. **Polycrystalline MoO3 films fabricated by pulsed laser deposition for infrared multilayer photonics**
Maria Cristina Larciprete, Daniele Ceneda, Chiyu Yang, Sina A. Dereshgi, Federico Vittorio Lupo, Maria Pia Casaletto, Roberto Macaluso, Mauro Antezza, Zhuomin M. Zhang, Marco Centini, Koray Aydin
20. **Design of a room-temperature topological exciton-polariton laser in a ZnO/TiO2 photonic crystal slab**
Charly Leblanc, I. Septembre, L. Hermet, H. S. Nguyen, X. Letartre, D. D. Solnyshkov, and G. Malpuech
21. **On-chip PI-excitonic materials: Manipulating multiple quantum states in a single quantum emitter and metallic nano-cavities accurately coupled systems**
Kun Liang, Li Yu
22. **Split Bowtie nanoantennas for electron acceleration**
Giovanni Magno, Marco Grande, Béatrice Dagens
23. **Computational study of interaction between Channelrhodopsin and a gold nanocluster**
Roberto Messina, Luca Bellucci, Stefano Corni, Stefania D'Agostino, Giuseppe Gigli, Laura Zanetti Polzi
24. **Effect of electron spill-out on the surface plasmon polariton propagation at dielectric-magnetized plasma interface.**

Tadele O. Otomalo, Muhammad Khalid, Cristian Ciracì

25. **Exciton-Plasmon Hybridization at interfaces of metal nanoparticles and 2D semiconductors**
Robert Salzwedel, Lara Greten, Stefan Schmidt, Stephen Hughes, Andreas Knorr, Malte Selig
26. **Monolithic van der Waals metasurfaces**
Luca Sortino, Stefan A. Maier, Andreas Tittl
27. **Manipulating light-matter interactions by strain modulation in two dimensional semiconductors**
Francesco Todisco, L. Polimeno, A. Di Renzo, R. Mastria, S. Rizzato, M. Mannoccio, M. Esposito, V. Tasco, K. Kurselis, R. Kiyan, M. De Giorgi, G. Maruccio, B. Chichkov, D. Sanvitto
28. **Metallic nanoislands-decorated tapered optical fibers for remote SERS sensing and heat generation**
Di Zheng, Filippo Pisano1, Liam Collard, Antonio Balena, Muhammad Fayyaz Kashif, Linda Piscopo, Cristian Ciracì, Massimo De Vittorio, Ferruccio Pisanello
29. **Spontaneous parametric down-conversion beaming from a Lithium Niobate nanoresonator**
Attilio Zilli, Vitaliy Sultanov, Michael Poloczek, Marzia Ferrera, Yigong Luan, Emmanouil Kokkinakis, Tomás Santiago-Cruz, Luca Carletti, Andrea Toma, Marco Finazzi, Maria Chekhova, Michele Celebrano

Friday, September 8th, 2023

Session 8 [09:00 – 10:40] Chair: Michael Scalora, US Army, USA

09:00 **Beam shaping and frequency conversion in nonlinear all-dielectric metasurfaces (Keynote)**

Jiannan Gao[1], Dmitrii Tsvetkov[1], Danilo Gomes Pires[1], Maria Antonietta Vincenti[2], Yun Xu[3], Ivan Kravchenko[4], Jesse Frantz[5], Anthony Clabeau[6], Xingdu Qiao[7], Liang Feng[8], Michael Scalora[9], Natalia M. Litchinitser[1]

[1]*Department of Electrical and Computer Engineering, Duke University, USA;* [2]*Department of Information Engineering, University of Brescia, Italy;* 31*Dassault Systemes Simulia Corp (CST), USA;* [4]*Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, USA;* [5]*US Naval Research Laboratory, USA;* [6]*University Research Foundation, USA;* [7]*Department of Electrical and Systems Engineering, University of Pennsylvania, USA;* [8]*Department of Materials Science and Engineering, University of Pennsylvania, USA;* [9]*Aviation and Missile Center, US Army CCDC, Redstone Arsenal, USA*

The emergence of nonlinear flat-optics nanostructures, optical metasurfaces, enabling unprecedented enhancement of light-matter interactions without phase-matching requirements may revolutionize future applications of integrated nonlinear optics. We demonstrate ultrafast tunable, near-infrared to ultraviolet frequency conversion in a chalcogenide glass metasurface based on Mie resonances and quasi-bound states in the continuum (qBIC) resonances, enabled by a phase-locking mechanism between the pump and the inhomogeneous portion of the TH signal. Through phase locking, the pump pulse and the inhomogeneous harmonic component can co-propagate, resulting in the acquisition of the same refractive index and absorption coefficient as the pump. If this process occurs within a cavity, efficient frequency conversion can take place, even in the presence of strong material absorption at the wavelengths of the harmonics. As for all nonlinear processes, a resonant condition at the pump field boosts the nonlinear interactions. We also experimentally show the simultaneous generation of phase-locked structured light beams, including optical vortices and Hopf-links at fundamental and tripled frequencies in all-dielectric nonlinear optical metasurfaces despite the fact that the tripled frequency is corresponding to the region of high absorption of the dielectric material. This work may have useful prospects in optical manipulation, optical communication, and quantum information transmission.

09:40 **Optical torque induced by resonant harmonic generation in dielectric nanostructures**

Mihail Petrov[1], Ivan Toftul[1,2], Gleb Fedorovich[1], Denis Kislov[1], Kristina Frizyuk[1], Kirill Koshelev[2], Yuri Kivshar[2]

[1]*Department of Physics and Engineering, ITMO University, Russia;* [2]*Australian National University, Australia*

Optically induced mechanical torque driving rotation of small objects requires the presence of absorption or breaking cylindrical symmetry of a scatterer. A spherical nonabsorbing particle cannot rotate due to the conservation of the angular momentum of light upon scattering. Here, we suggest a novel physical mechanism for the angular momentum transfer to nonabsorbing particles via nonlinear light scattering. The breaking of symmetry occurs at the microscopic level manifested in nonlinear negative optical torque due to the excitation of resonant states at the harmonic frequency with higher projection of angular momentum. The proposed physical mechanism can be verified with resonant dielectric nanostructures, and we suggest some specific realizations.

10:00 **2D semiconductor multilayers for ultra-thin nanophotonic platform**

Su-Hyun Gong

Department of Physics, Korea University, South Korea

The emergence of 2D materials stimulated intensive research on both electronic and photonic applications. Especially, transition metal dichalcogenides (TMDs) provided an excellent platform for photonic applications due to their strong light-exciton interaction. Various photonic devices such as a light-emitting device, laser, and exciton-polariton device have been successfully demonstrated experimentally using TMD monolayers. However, multilayered TMDs have attracted far less attention than TMD monolayers because they become indirect bandgap materials. Here I will present that multilayered TMD itself is a good platform for controlling light-matter interaction without integrating an external photonic structure. A TMD multilayer can be utilized for a passive optical structure because it possesses a high dielectric constant. For example, light guiding is possible along a multilayered TMD, which is very thin compared to the wavelength of light. Because a high dielectric constant is owing to the exciton resonances, guided light along a TMD layer is referred to as exciton-polariton. I will also show that light can be further controlled using a patterned TMD multilayer. A patterned WS2 disk structure has a very high confinement factor for lasing action because the TMD disk offers both optical modes and optical gains. As a result, we observed the lasing operation under continuous-wave excitation at room temperature. We believe our results show potential for the TMD-based nanophotonics offering a small mode volume but with a lower loss compared to the surface plasmon polaritons.

11:00 **Making spatial dispersion useful**

Antoine Moreau[1], Émilie Sakat[2], Jean-Paul Hugonin[3] and Thierry Taliercio[4]
[1]*Université Clermont Auvergne, CNRS, Institut Pascal, Clermont-Ferrand, France;* [2]*Université Paris Saclay, Center for Nanoscience and Nanotechnology, CNRS, Palaiseau, France;* [3]*Université Paris-Saclay, Institut d'Optique Graduate School, CNRS, Palaiseau, France;* [4]*IES, Université de Montpellier, UMR CNRS 5214, Montpellier, France*

For more than a century, the accuracy of the Drude model for describing the response of media containing an electron gas has been such that there was no use of more advanced models. This has changed ten years ago when the first signs of spatial dispersion in metals have been observed – however the importance of this effect is relatively modest. This may not be the case for doped semi-conductors, in which the effective mass is small enough for spatial dispersion to have a distinctive impact that can not be neglected or explained by any other phenomenon. This can even be leveraged to retrieve, thanks to a single optical measurement, all the characteristics of the material (doping and effective mass) making spatial dispersion truly useful in that case.

Session 9 [11:10 – 12:10] Chair: Francesco Todisco, CNR NANOTEC, Italy

11:10 **Nonlinear nanoplasmonics with atomically thin materials**

Joel Cox
POLIMA–Center for Polariton-driven Light-Matter Interactions, University of Southern Denmark, DK-5230 Odense M, Denmark; Danish Institute for Advanced Study, University of Southern Denmark, DK-5230 Odense M, Denmark

Plasmons–collective oscillations in the free electron plasma–constitute nanoscale optical resonators that are imbued with a nonlinear response by their supporting conductive media. In the 2D limit represented by atomically thin materials, plasmon resonances provide unprecedented levels of optical field confinement, while exhibiting relatively lower losses in pristine samples. The appealing properties of 2D plasmons are ideal for nonlinear plasmonics, which seeks to overcome the weak nonlinear response of available materials by exploiting the large near field enhancement supplied by plasmon resonances. Here we theoretically explore nonlinear light-matter interactions of 2D plasmons hosted in atomically thin materials and their heterostructures. Our investigations are based on nonclassical methods to describe graphene plasmons, characterized by high confinement and electrical tunability, plasmons supported by ultrathin crystalline noble metal films, with thickness-dependent properties and lower losses than their amorphous counterparts, and nanostructured phosphorene, an anisotropic two-dimensional semiconductor that hosts plasmons in highly-doped samples. We further explore possibilities to trigger nonlinear interactions on the few-plasmon level and to enhance harmonic generation through synergetic interactions between plasmons in atomically-thin heterostructures.

11:30 **Free-electron infrared nonlinearities in heavily doped InGaAs nanoantennas**

Tommaso Venanzi[1], M. Ortolani[2], V. Giliberti[1], A. Rossetti[3], T. Deckert[3], D. Brida[3], M. Pea[4], A. Bousseksou[5], L. Lucia[5], I. Sagnes[5], G. Beaudoin[5], R. Colombelli[5], H. Hu[6], F. De Luca[6], C. Ciracì[6]
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Hydrodynamic models of free electrons in metals and in degenerately doped semiconductors can describe accurately a range of nanoscale plasmonic phenomena that occur at interfaces, nanoantennas, metasurfaces. Within the hydrodynamic model, third-order nonlinear terms arise, especially when the free electrons are driven at frequencies close to their plasma frequency. In the project NEHO, we aim to employ free-electron nonlinearities in n-doped InGaAs as non-linear process to make optical computation in mid-infrared integrated photonic circuits. As first step of the project, we quantify the third-order free-electron non-linearity by measuring third-harmonic generation of plasmonic antenna arrays. We fabricated antennas with different plasma frequencies and, therefore, with different plasmonic resonance frequencies (8.5, 9.8, 11.3 um). The third harmonic generation (THG) is strongly enhanced when the mid-infrared pump wavelength matches the plasmonic resonance of the array. No THG is observed from the undoped antenna array confirming that the TH originates from the non-linear response of free electrons.

11:50 **Passive and tunable flat optics with dielectric nanoantennas**

Arseniy Kuznetsov
*Institute of Materials Research and Engineering, A*STAR (Agency for Science, Technology and Research), Singapore*

Dielectric nanoantennas and metasurfaces have recently emerged as a new nanophotonic platform paving way to new generation of flat optical components. They can control light at nanometer dimensions in an unprecedented fashion, not achievable by conventional bulk optics. This led to demonstrations of flat optics with extraordinary performance, e.g. very large numerical aperture or very large field of view. One of the existing challenges of metasurface-based flat optics is strong grating-like dispersion of metasurfaces, which typically limits their ability to perform high-quality imaging in a broad spectral range, e.g., with white light. In this talk, I will first show how combining a few large-field of view quadratic metalenses with image-processing it is possible to achieve white-light wide-field-of-view imaging potentially applicable to regular smartphones or laptops. On the other hand, I will also demonstrate that the metasurface dispersion can be used in a constructive way to achieve hyperspectral imaging systems for space applications. I will then demonstrate that integrating these nanoantennas on top of actively controlled 1D and 2D electrode arrays embedded in liquid crystals it is possible to achieve fully controllable and dynamically switchable metasurfaces with a pixel size down to 1 micrometer. These metasurface-based spatial light modulators can generate arbitrary wavefront patterns and can be used for beam steering in LiDAR devices or tunable holography in 3D holographic displays.

List of Presenters

Alexandre Baron, University of Bordeaux, France
Sergejs Boroviks, EPFL, Switzerland
Alexandre Bouhelier, CNRS, France
Daniele Brida, University of Luxembourg, Luxembourg
Salvatore Buonocore, Istituto Italiano di Tecnologia, Italy
Lucia Cascino, University of Salento, Italy
Michele Celebrano, Politecnico di Milano, Italy
Marco Centini, Sapienza, University of Rome, Italy
Crina Cojocaru, Universitat Politècnica de Catalunya, Spain
Adriano Cola, IMM-CNR, Italy
Joel Cox, University of Southern Denmark, Denmark
Angus Crookes, University of Birmingham, U.K.
Cristina Cruciano, Politecnico di Milano, Italy
Stefania D'Agostino, CNR NANOTEC, Italy
Domenico de Ceglia, University of Brescia, Italy
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Muhammad Fayyaz Kashif, Instituto Italiano di Tecnologia, Italy
Stéphane Kena-Cohen, Polytechnique Montreal, Canada
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Roberto Messina, Università del Salento, Italy
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Antoine Moreau, Université Clermont Auvergne, France
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