

# METAMATERIALS 3.1

CONFERENCE PROGRAMME



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**EPS SYMPOSIUM ON THE THIRD  
GENERATION METAMATERIALS**

1 - 5 August 2022, Cetraro, Calabria, Italy

[www.third-generation-metamaterials.org](http://www.third-generation-metamaterials.org)

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**Programme Information**

The papers included in this programme comprise the short summaries of the EPS Symposium on the Third Generation Metamaterials (METAMATERIALS 3.1) held in Cetraro, Calabria, Italy from August 1<sup>st</sup> to 5<sup>th</sup>, 2022.

The extended version of the papers (1-page summaries in pdf format) will be made available online during a time period of 2 months beginning from the conference. A link with login and password is provided on a separate sheet.

All web browsers (Firefox, Internet Explorer, Safari or similar) will allow you to download the digest. A .pdf viewer (tested with Adobe Acrobat) will be necessary to view the papers. This software can be downloaded from <http://www.adobe.com>

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**EPS Symposium on the Third Generation Metamaterials (METAMATERIALS 3.1), 1 – 5 August 2022, Cetraro, Calabria, Italy**

We are delighted to announce the EPS Symposium on the Third Generation Metamaterials (METAMATERIALS 3.1) to take place from August 1<sup>st</sup> to 5<sup>th</sup>, 2022 at the **Grand Hotel San Michele**, Contrada Bosco, 8, 87022 Boscorvara CS, Italy (<https://www.grandhotelsanmichele.it/>) located 5 km away from Cetraro, province of Cosenza, Calabria region, Italy (Phone: +39 0982 91012).

Over the years the field of metamaterials has evolved from engineering artificial media with exotic properties such as negative and zero refractive indices, chirality, optical magnetism, epsilon-near-zero features and other characteristics (the first generation) to the development of tunable, switchable and reconfigurable metamaterials and metasurfaces (the second generation). This field has now entered into its third generation, as it is rapidly expanding into the domain of quantum technologies, artificial intelligence and topological photonics. This Symposium organized by the European Physical Society will aim to be a discussion forum exploring this evolving research direction.

The symposium will consist in an invitation-only scientific workshop devoted to the next generation of electromagnetic metamaterials that are rapidly expanding into the domain of quantum technologies, artificial intelligence and topological photonics. It will also be a platform for broad discussions on the future of photonics.

It will also be an occasion to celebrate the **65th+2 birthdays** of two metamaterial pioneers whose vision and scientific achievements seminally inspired the first generation, advanced the second generation, and continue to lead the path for the third generation of metamaterial science and technology:



**Nader Engheta**, *University of Pennsylvania, USA,*



**Nikolay Zheludev**, *University of Southampton, UK and NTU Singapore*

Conference Co-Chairs



**Andrea Alù**, *The City University of New York, CUNY (USA)*



**Kevin MacDonald**, *University of Southampton (UK)*



**Cesare Soci**, *Nanyang Technological University, NTU (Singapore)*



**Giuseppe Strangi**, *Case Western Reserve University, Cleveland, OH (USA)*



**Key Dates of the Symposium**

Arrival and Welcome Reception: Tuesday 1 August 2022

Symposium: From Tuesday 2 to Thursday 4 August 2022

Symposium Dinner: Thursday evening 4 August 2022

Conference excursion to Aeolian Islands: Friday 5 August 2022 (all day, at additional cost).

The programme will feature **53 invited presentations**.

**Speakers' Information**

Speakers are asked to check-in with the session chair in the conference room ten minutes before the session begins. The conference room called "Sala Crati" is equipped with audio system (microphones, loudspeakers), video system (screen, projector), computer, chalkboard, wifi and air-conditioning. Presenters may transfer their presentation files by USB memory stick.



Invited presentations will be 20 minutes including discussion. Closing talks will be 30 minutes including discussion.

Discussion themes will be featured during the first two symposium days:

Tuesday 2 August 2022: **Photonic technologies. Is it all over?**

Wednesday 3 August 2022: **What will our research be in 10 years from now?**

**Symposium Dinner**

The dinner will take place at the Grand Hotel San Michele on Thursday 4 August 2022, beginning from 20:30. It will be followed by a concert from the **Hetty and the Jazzato Band**.

**Symposium Language**

The official language is English.

**Registration and Social Programme**

The registration fees for the meeting include:

- Welcome reception on Monday 1 August 2022, beginning from 19:00.
- Admission to all technical sessions of the symposium.
- Coffee breaks as mentioned in the programme.
- Printed and online programme. See <http://www.third-generation-metamaterials.org/program/>
- Online technical digest gathering the 1-page summaries. A login and password will be given to access it.
- Conference dinner and the “**Hetty and the Jazzato Band**” concert to take place on Thursday evening 4 August 2022.

Full board (breakfast, lunch and dinner) is included in the reservations done at the Grand Hotel San Michele. Drinks (water and 1/4 liter of wine per person) are also included. **Long trousers are required for gentlemen during dinner.**

Transportation tickets are excluded.

No on-site registration is scheduled. The EPS desk will open beginning from Monday 1 August 2022 from 18:00 to 19:00.

**Optional Mini Cruise on Friday 5 August 2022**

An optional mini cruise to Aeolian Islands is proposed. The Aeolian Islands, sometimes referred to as the Lipari Islands or Lipari group after their largest island, are a volcanic archipelago in the Tyrrhenian Sea North of Sicily, named after the demigod of the winds Aeolus. The islands' inhabitants are known as Aeolians. Symposium participants have the opportunity to join the mini cruise to the Aeolian Islands (Stromboli – Lipari – Vulcano). Special prices to visit these three stunningly beautiful aeolian islands (<https://www.tropea-isole-eolie-comerci.it/en/>) were negotiated. Those wishing to attend the excursion, need to extend their stay at the Grand Hotel S. Michele by one night and plan to leave on Saturday August 6th, 2022. Excursion time schedule: Departure from Hotel (5am, Friday 5 August 2022) – Return to the Hotel (8pm). Cost: Euro 100 per person, Euro 75 per Child < 12 years old. The mini cruise will depart August 5th at 7am from Vibo Marina. A small town 100 Km South of Cetraro. The excursion required registration in advance using the online registration system. No onsite registration.

**Symposium/Welcome Reception Hours**

Tuesday 1 August 2022: 19:00 – 20:30 Welcome Reception  
Tuesday 2 August 2022: 08:30 – 12:00 / 16:00 – 19:20 Sessions  
Wednesday 3 August 2022: 08:50 – 12:20 / 16:00 – 19:20 Sessions  
Thursday 4 August 2022: 08:50 – 12:20 / 16:00 – 19:30 Sessions

**Opening Hours of the EPS Desk**

Tuesday 1 August 2022: 18:00 – 19:00  
Tuesday 2 August 2022: 08:00 – 11:30 / 15:45 – 17:30  
Wednesday 3 August 2022: 08:30 – 11:30 / 15:45 – 16:30  
Thursday 4 August 2022: 08:30 – 11:00

**Photography**

Attendance at, or participation in the symposium constitutes consent to the use and distribution by the European Physical Society of the attendees' image for informational, publicity, promotional and/or reporting purposes in print or electronic communications media.

Video recording by participants and other attendees during the conference is not allowed. Photographs of PowerPoint or other slides are for personal use only and are not to be reproduced or distributed.

**Symposium Management**

The European Physical Society provides the symposium management, 6 rue des Frères Lumière, 68200 Mulhouse, France. This programme is edited by P. Helfenstein and A. Wobst.



### Symposium Location

The EPS Symposium “**Third Generation Metamaterials**” will take place in the **Grand Hotel San Michele**. It is an elegant villa with golf and a beach facility located on the mountain slope overlooking the **Tyrrhenian Sea**. From here, the view is simply superb. Looking over the terraces on a clearer day you can see the Aeolian Islands or enjoy a beautiful sunset. The green landscape in which the building is immersed - a good 44 hectares - gives the hotel a quiet peaceful atmosphere where you can regain vital energy easily through contact with nature. It is close to the villages of **Cetraro** and **Paola**, in the province of Cosenza (Calabria), South of Italy.

**Grand Hotel San Michele address:**  
**Contrada Bosco, 8, 87022 Bosco-arvara CS,**  
**Italy (phone: +39 0982 91012).**

A quota of rooms at special rates was reserved for the participants of the Third Generation Metamaterials Symposium.

Wireless internet available. Request it at the hotel.

### **The region of Calabria**

Calabria is at the toe of the boot, the extreme South of Italy – lapped by the splendid crystal blue Ionian and Tyrrhenian Seas and separated from Sicily by the Strait of Messina. The warm climate, the beautiful colours of the sea, rocky coasts that alternate with sandy beaches, a nature that is wild and mysterious, the strong and genuine flavours of local food and the vestiges of its ancient origins make Calabria a unique place that vacationers can enjoy in both winter and summer.

The provinces of Calabria are:

Catanzaro (regional capital), Reggio Calabria, Cosenza, Crotone and Vibo Valentia.

The symposium will take place **5km North of Cetraro**, in province of Cosenza. It is one of the most populated provinces in Italy and the eighth for extension. With its 367 miles of coast, the Province of Cosenza occupies 44.1% of the surface of Calabria, essentially the entire central and northern part of the region.



**How to Reach the Hotel?**

The Grand hotel San Michele, Contrada Bosco, 8, 87022 Bosco-arvara CS, Italy (phone: +39 0982 91012) is close to the villages of Cetraro and Paola.

The nearest airport to the hotel is the **Lamezia Terme airport**, 1 hour and half by car, with connections from Athens, Bratislava, Basel, Berlin, Dusseldorf, Frankfurt, Hannover, London, Milan, Moscow, Paris, Prague, Rome, Toronto, Zurich and many others. From there a shuttle service can be ordered in advance (see instructions below). Alternatively, one can land at the airport of Naples Capodichino and reach Cetraro by train (more or less 4 hours) or transit via Rome airports.

Grand Hotel San Michele can then be reached by car or direct trains to Paola. Paola train station is just 25km away from the hotel. From there a shuttle service can be ordered in advance (see instructions below).

For train tickets look at: [www.thetrainline.eu](http://www.thetrainline.eu).

Indicative travel times to the hotel:

Self-drive from Lamezia Terme airport: 1 h 15 min (87km).

Direct train from Lamezia Terme Centrale to Paola: 28mm/33m

Self-drive from Naples airport: 3 h 8 min (261 km)

Direct train from Naples Centrale to Paola: 2h40m/3h30m

From Rome airports, one can either:

Rent a car and drive South for 5 hours.

Take the train from Rome Fiumicino airport to Stazione Termini (Rome), and then take the train to Paola (3 hours).

Take a plane from Rome airport to Lamezia Terme airport (code SUF).

Shuttle service (Collective transfers with driver) operated by Top Class from Lamezia Terme airport or Paola train station and vice versa

From Paola FS or Lamezia APT, a shuttle service operated by a travel agency Top Class can be ordered in advance per email.

The following rates, although on a collective basis, are also guaranteed in the presence of a single participant.

The organizational secretariat for the mobility of the entire event is included:

- management of communications with the individual participant.
- sending detailed confirmation to the individual participant on the day of the request.
- sending travel details to the individual participant the day before each service (assigned driver number, exact pick-up time).
- help number throughout the event.

Costs:

Lamezia Terme airport / Cetraro or vice versa € 70.00 per person one way.

Couple rate in case of booking made by 2 people together € 100.00 one way.

Children (minors) under 18 years if accompanied by at least 1 adult € 25.00 one way.

Obligatory baby seat for children under 12 € 8.00 one way.

Paola railway station / Cetraro or vice versa € 40.00 per person one way.

Couple rate in case of booking made by 2 people together € 65.00 one way.

Children (minors) under 18 years if accompanied by at least 1 adult € 15.00 one way.

Obligatory baby seat for children under 12 € 8.00 one way.

To book, send an email to: [ncc@topclassturismo.com](mailto:ncc@topclassturismo.com)

in the subject specify: METAMATERIALS 3.1 YEAR 2022, Grand Hotel San Michele

required data:

- name surname
- mobile phone active in Italy
- number of passengers (in the case of minors, specify the age)
- date of arrival, arrival time in Lamezia (flight number) or in Paola (train number)
- departure date, flight departure time from Lamezia (flight number) or from Paola (train number).

**Covid-19 Rules**

The conference management will only be able to accept participants who fulfil the Covid-19 rules in effect in Calabria. Please check rules: <https://www.italia.it/en/covid19>. Check Covid-19 situation in Italy (<https://www.salute.gov.it/portale/nuovocoronavirus/dettaglioContenutiNuovoCoronavirus.jsp?lingua=english&id=5367&area=nuovoCoronavirus&menu=vuoto>). As of June 1, 2022, a Green Pass or equivalent certificate is no longer needed to enter Italy.

During your stay in Italy

**Green Pass**

Effective from May 1, 2022, **it is no longer mandatory to show a Green Pass to access businesses and services in Italy**. Therefore, free access to local and national public transportation, bars and restaurants, shops, museums, theatres, cinemas, stadiums, gyms, spas, etc.

**Use of masks**

**Until September 30, 2022 the use of FFP2 masks remains mandatory aboard the following means of transport:**

Ships and ferries used for interregional transport services  
High Speed, Intercity, Intercity Night, and Interregional Trains  
Buses connecting more than two regions  
Buses/coaches used for chartered services with driver  
Local and regional public transport

The use of a mask is no longer mandatory on airplanes and for access to indoor shows and sporting events. However, **the use of the mask in all indoor environments** and in all cases of crowded outdoor events **is highly recommended**.

Please note that nonetheless, in all situations, the following people are **excluded from the requirement to wear masks**:

Children under the age of six  
Persons with a medical condition or disability that is incompatible with the use of a mask, and persons who must communicate with a disabled person  
Individuals who are engaging in athletic activities

Find out the requirements for entry to Italy by clicking on [viaggiaresicuri.it](https://viaggiaresicuri.it).

Information on the EU Digital COVID Certificate ([https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/safe-covid-19-vaccines-europeans/eu-digital-covid-certificate\\_en](https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/safe-covid-19-vaccines-europeans/eu-digital-covid-certificate_en)).

**Weather in Cetraro in August**

Temperature hovers around 28°C (82,4 °F) and at night it feels like 22°C (71,6 °F). In August, Cetraro gets 31.25mm of rain and approximately 2 rainy days in the month. Humidity is close to 67%. This makes August one of the hottest month of the year.

**Currency**

Euro is the official currency in Italy.

Major credit cards (VISA, MasterCard/Euro card, American Express, Diners...) are generally accepted in airports, train stations, hotels, larger shop, etc.





**Programme at a Glance:**

Session	Session title	Location	Day	Date	Session begin	Session end
<b>MON-1</b>	Welcome Reception	Lounge/Bar Terrace	Monday	August 1, 2022	19:00	20:30
	Dinner (*)	Main Restaurant Terrace	Monday	August 1, 2022	20:30	22:00
<b>TUE-1</b>	Chairs' Welcome and Session 1	Sala Crati	Tuesday	August 2, 2022	8:30	10:10
	Coffee Break	Bar Terrace	Tuesday	August 2, 2022	10:10	10:40
<b>TUE-2</b>	Session 2	Sala Crati	Tuesday	August 2, 2022	10:40	12:00
	Lunch	Restaurant by the Sea	Tuesday	August 2, 2022	12:00	13:45
<b>TUE-3</b>	Session 3	Sala Crati	Tuesday	August 2, 2022	16:00	17:20
	Coffee Break	Bar Terrace	Tuesday	August 2, 2022	17:20	17:40
<b>TUE-4</b>	Session 4	Sala Crati	Tuesday	August 2, 2022	17:40	19:20
	Dinner and Discussion Theme: Photonic Technologies. Is it all over? (*)	Main Restaurant Terrace	Tuesday	August 2, 2022	20:30	22:30
<b>WED-1</b>	Session 1	Sala Crati	Wednesday	August 3, 2022	08:50	10:10
	Coffee Break	Bar Terrace	Wednesday	August 3, 2022	10:10	10:40
<b>WED-2</b>	Session 2	Sala Crati	Wednesday	August 3, 2022	10:40	12:20
	Lunch	Restaurant by the Sea	Wednesday	August 3, 2022	12:20	14:00
<b>WED-3</b>	Session 3	Sala Crati	Wednesday	August 3, 2022	16:00	17:20
	Coffee Break	Bar Terrace	Wednesday	August 3, 2022	17:20	17:40
<b>WED-4</b>	Session 4	Sala Crati	Wednesday	August 3, 2022	17:40	19:20
	Dinner and Discussion Theme: What will our research be in 10 years from now? (*)	Main Restaurant Terrace	Wednesday	August 3, 2022	20:30	22:30
<b>THU-1</b>	Session 1	Sala Crati	Thursday	August 4, 2022	08:50	10:10
	Coffee Break	Bar Terrace	Thursday	August 4, 2022	10:10	10:40
<b>THU-2</b>	Session 2	Sala Crati	Thursday	August 4, 2022	10:40	12:20
	Lunch	Restaurant by the Sea	Thursday	August 4, 2022	12:20	14:00
<b>THU-3</b>	Session 3	Sala Crati	Thursday	August 4, 2022	16:00	17:20
	Coffee Break	Bar Terrace	Thursday	August 4, 2022	17:20	17:40
<b>THU-4</b>	Session 4	Sala Crati	Thursday	August 4, 2022	17:40	18:20
	Closing Ceremony	Sala Crati	Thursday	August 4, 2022	18:20	19:00
<b>THU-5</b>	Closing Talks	Sala Crati	Thursday	August 4, 2022	19:00	20:00
	Dinner and Concert (*)	Main Restaurant Terrace	Thursday	August 4, 2022	20:30	22:30
	Optional excursion		Friday	August 5, 2022	05:00	20:00

(\*) Long trousers are required for gentlemen during dinner.

## MON-1: Welcome Reception

Time: Monday, 19:00–20:30

Location: Sala Crati

## Welcome Reception

**NOTES:**

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

## TUE-1: Chairs' Welcome and Session 1

Chaired by Andrea Alù - The City University of New York (CUNY) - USA

Time: Tuesday, 8:30–10:10

Location: Sala Crati

**Chairs' Welcome by Andrea Alù, Kevin MacDonald, Cesare Soci and Giuseppe Strangi**

### Invited

TUE-1.1 8:50

**Wavefront shaping for wireless communications with Intelligent Metasurfaces** — •MATHIAS FINK — Langevin Institute, ESPCI Paris, PSL University, Paris, France

I will show how, by introducing a tunable metasurface in any wireless environment, one can physically reshapes the propagation medium to achieve optimal connection between several antenna. I will discuss this concept both in the case of narrowband and broadband communication.

### Invited

TUE-1.2 9:10

**Spin-valley Rashba monolayer light sources** — •EREZ HASMAN — Technion, Haifa, Israel

Heterostructures combining a thin layer of quantum emitters and planar nanostructures enable custom-tailored photoluminescence in an integrated fashion. Here, we demonstrate a photonic Rashba effect from valley excitons in a WSe<sub>2</sub> monolayer, which is incorporated into a photonic crystal slab with geometric phase defects–Berry phase defective photonic crystal. These spin-enabled manipulation of quantum emitters opens the avenues for highly effective metasurfaces for customized planar sources.

### Invited

TUE-1.3 9:30

**Quantum Meta-Photonics** — •VLADIMIR SHALAEV — School of Electrical and Computer Engineering, Birck Nanotechnology Center and Purdue Quantum Science and Engineering Institute, Purdue University, West Lafayette, IN 47906, USA

We discuss important challenges in the emerging quantum technology and possible means to address them with ultrafast plasmonic metamaterials, scalable photonic material platforms and advanced machine-learning designs.

### Invited

TUE-1.4 9:50

**Mid-infrared nonlocality and electrical generation** — CHRISTOPHER R. GUBBIN and •SIMONE DE LIBERATO — School of Physics and Astronomy, University of Southampton, Southampton

Phonon polaritons are an important platform in mid-infrared nanophotonics. We show how at the nanoscale the propagation of optical phonons cannot be neglected and results in a nonlocal optical response. In turn this leads to the creation of hybridized longitudinal-transverse charge oscillations. These excitations can be electrically excited through their longitudinal component and emit photons through their transverse one, providing a new pathway to electrical generation of mid-infrared radiation.

**10:10–10:40: Coffee Break**



## TUE-2: Session 2

Chaired by Andrea Alù - The City University of New York (CUNY) - USA

Time: Tuesday, 10:40–12:00

Location: Sala Crati

**Invited**

TUE-2.1 10:40

**Integrated Circuits Based on Pixel-Array Metasurfaces for Generating Data-Carrying Optical and THz Orbital-Angular-Momentum Beams** — •ALAN WILLNER — University of Southern California, Los Angeles, CA, USA

Integrated circuits hold the promise of reduced size and cost when generating and detecting beams of a specific modal order of orbital-angular-momentum (OAM). This presentation will describe various pixel-array-based metasurface structures that can emit multiple OAM beams in photonic and THz frequency regions. Key systems issues will be described, including: (i) transmitting phase-shift-keyed data over a broad spectral band, and (ii) tuning the mode order.

**Invited**

TUE-2.2 11:00

**New Materials and Approaches for Dynamic Wavefront Manipulation** — •MARK BRONGERSMA — Stanford University, USA

In this presentation, I will highlight recent efforts in our group to realize electrically-tunable metasurfaces employing nanomechanics, tunable transparent oxides, electrochemistry, microfluidics, phase change materials, and atomically-thin semiconductors. Such elements are capable of dynamic wavefront manipulation for optical beam steering, wavefront manipulation, and future displays.

**Invited**

TUE-2.3 11:20

**Leveraging large anisotropy and strong coupling in polaritonic systems** — •JOSHUA CALDWELL — Vanderbilt University, Nashville, TN USA

IR nanophotonics requires sub-diffractive confinement of light, typically through the formation of polaritons. The use of highly anisotropic polaritonic materials and through polaritonic strong coupling control of nanoscale light propagation can be realized. This talk discusses how low symmetry crystals and strong coupling can give rise to novel optical phenomena such as hyperbolicity and shear polaritons, for controlling the spatial and spectral coherence of thermal radiation and ultrafast thermal dissipation.

**Invited**

TUE-2.4 11:40

**Nanoplasmonic and nanophotonic active devices** — •URIEL LEVY, ZHENGLI HAN, AHARON WEISS, CHRISTIAN FRYDENDAHN, S.R.K. CHAITANYA INDUKURI, RIVKA GHERABLI, JACOB ENGELBERG, and NOA MAZURSKI — The Hebrew University of Jerusalem, HUJI, Department of Applied physics and the Center for Nanoscience and Nanotechnology, Israel

We present our recent results related to the tunability of dielectric and metallic metasurfaces for diverse applications. Two major mechanisms will be discussed, 1- MEMS technology integrated with metasurfaces and 2 - electro optic effect in lithium niobate integrated with metasurfaces. We also discuss the role of nanoscale structures in enhancing functionalities such as light emission and light detection. Finally, we present how metalenses can be used for 3-D imaging.

**12:00–16:00: Lunch and Break**

## TUE-3: Session 3

Chaired by Kevin MacDonald - University of Southampton - UK

Time: Tuesday, 16:00–17:20

Location: Sala Crati

**Invited**

TUE-3.1 16:00

**High-performance Flat optics based on Metasurfaces from the near IR to the XUV** — •FEDERICO CAPASSO — Harvard University

I will give an overview of research by my group on flat optics for high volume commercial applications ranging from consumer electronics to communications, leading to the first mass manufacturing by a semiconductor company of metaoptics. Recent results on extending metaoptics to the XUV ( $\lambda=50$  nm) will be presented

**Invited**

TUE-3.2 16:20

**Chalcogenide Reconfigurable Metamaterials** — •BEHRAD GHOLIPOUR — Nanoscale Optics Lab, Electrical and Computer Engineering Dept, Edmonton, Canada

Chalcogenides, alloys of sulfur, selenium and tellurium, present various high- and low-index dielectric, low-epsilon and plasmonic properties across ultra-violet to infrared frequencies, in addition to a, non-volatile, electrically/optically induced switching capability between amorphous and crystalline phases with markedly different electromagnetic properties. We show recent efforts in integration of these semiconductors as metamaterials within optical fibres, waveguides and freespace platforms for intensity and dispersion control with applications in telecommunication and computing.

**Invited**

TUE-3.3 16:40

**Pragmatic approach to applications of metamaterials for biomedical imaging: Multi-resonant interactions mediated by metamaterial structures** — •VLADISLAV V. YAKOVLEV — Texas A&M University, College Station, Texas, 77845, USA

Metamaterial structures are important for biomedical imaging and sensing since they can offer potential capabilities which are not accessible by traditional optical techniques. We have recently utilized metasurfaces to enhance spatial resolution and contrast of spectroscopic imaging by utilizing multiple resonant interactions.

**Invited**

TUE-3.4 17:00

**Metasurfaces for biomedical applications: A nanophotonics perspective** — •GIUSEPPE STRANGI — Case Western Reserve University, Cleveland, USA and NLHT Laboratory, University of Calabria and CNR NAN-OTEC, Rende, Italy

The crossroad between nanoscience and biology is becoming a relevant and fertile research field, where light-matter interaction is manipulated at the single nanometer scale for cellular explorations, high-resolution imaging and advanced nanotherapies. This talk will review how we harness and control the interaction between light and matter at this scale by engineering artificial functional metasurfaces with fascinating extreme optical properties.

17:20–17:40: Coffee Break

## TUE-4: Session 4

Chaired by Kevin MacDonald - University of Southampton - UK

Time: Tuesday, 17:40–19:20

Location: Sala Crati

**Invited**

TUE-4.1 17:40

**Optical thermodynamics of nonlinear highly multimode systems** — •DEMETRI CHRISTODOULIDES — CREOL -University of Central Florida, Orlando, FL USA

In this talk, a thermodynamic theory capable of describing complex, highly multimoded, nonlinear optical systems is presented.

**Invited**

TUE-4.2 18:00

**Plasmonic metamaterials meet living cells: Towards novel drug screens and single-cell imaging modalities** — •GENNADY SHVETS — Cornell University, Ithaca, NY, USA

I will describe an experimental technique developed in our lab – Metasurface-Enhanced Infrared Reflection Spectroscopy (MEIRS) of live cells – used to interrogating the effects of various chemical compounds on cellular membranes and cytoskeleton. MEIRS relies on the nano-bio interface between plasmonic nanostructures and the cells to probe phenotypic changes, such as cell adhesion, response to drugs, and intra-cellular protein transport.

**Invited**

TUE-4.3 18:20

**Distributed transistor-type response in electrically biased 2D materials** — TATIANA RAPPOPORT<sup>1</sup>, TIAGO MORGADO<sup>2</sup>, SYLVAIN LANNEBERE<sup>2</sup>, and •MARIO SILVEIRINHA<sup>1</sup> — <sup>1</sup>University of Lisbon and Instituto de Telecomunicações — <sup>2</sup>University of Coimbra and Instituto de Telecomunicações

Semiconductor transistors are key elements of electronic circuits. Conventional transistors are point-type devices. Here, we will show that low-symmetry two-dimensional metallic systems may be the ideal platforms to implement a distributed-transistor response. We will outline several exciting applications for 2D materials with a distributed-type transistor response, and present our vision why such materials can lead to a new generation of active and nonreciprocal terahertz devices.

**Invited**

TUE-4.4 18:40

**PT-symmetric terahertz photoconductivity in the topological phase of Hg<sub>1-x</sub>Cd<sub>x</sub>Te semiconductors** — •DMITRY R. KHOKHLOV — Moscow State University, Russia

We show that the terahertz (THz) photoconductivity in the topological phase of Hg<sub>1-x</sub>Cd<sub>x</sub>Te-based structures exhibits the apparent PT- (parity-time) symmetry whereas the P-symmetry and the T-symmetry, separately, are not conserved. We demonstrate that the breaking of P- and T-symmetries is due to the appearance of nonlocal edge photoconductivity under the action of terahertz radiation pulses. Edge photocurrents are chiral and odd in magnetic field and applied voltage.

**Invited**

TUE-4.5 19:00

**Invited Talk** — •BORIS LUKYANCHUK — Lomonosov Moscow State University, Moscow, Russia

**20:30–22:30: Dinner and discussion theme: Photonic technologies. Is it all over?**



## WED-1: Session 1

Chaired by Cesare Soci - Nanyang Technological University - Singapore

Time: Wednesday, 8:50–10:10

Location: Sala Crati

### Invited

WED-1.1 8:50

**Metasurface Laser Lightsails** — •HARRY ATWATER — Caltech, United States

Nanophotonic design principles can enable self-stabilizing optical manipulation, levitation and propulsion of ultralight macroscopic-sized (i.e., mm, cm, or even meter-scale) metasurface ‘lightsails’ via radiation pressure from a high power density pump laser source. Here we examine stringent criteria for the lightsail materials design, thermal management, and dynamical stability, and discuss lightsail design and first experimental steps in characterization of small (<1 mm) microscale lightsails.

### Invited

WED-1.2 9:10

**Photonics for Energy and Extreme Optics: From Materials to Design** — •ALEXANDRA BOLTASSEVA — Purdue University, West Lafayette, IN, USA

The field of metasurfaces is currently driving the development of novel applications in sustainable energy and extreme optics that deals with elevated temperatures and high powers. We explore the potential of robust photonic materials including transition metal nitrides (titanium nitride, zirconium nitride) and transparent conducting oxides (TCOs) for a wide range of nanophotonic applications including switchable photonics, high-harmonic-based XUV generation, high-temperature stable metasurfaces for energy conversion and photocatalysis.

### Invited

WED-1.3 9:30

**Polaritonics in two-dimensional materials** — •JAVIER GARCIA DE ABAJO — ICFO-Institut de Ciències Fotòniques, Barcelona, Spain

We will discuss recent advances in the study of fundamental aspects and applications of polaritons in two-dimensional materials.

### Invited

WED-1.4 9:50

**Toroidal Electrodynamics: From Non-Radiating Anapoles to Supertoroidal Pulses** — •NIKITAS PAPASIMAKIS — University of Southampton, Southampton, UK

This talk will provide an overview of the research field of toroidal electrodynamics with a focus on recent developments in the study of toroidal light pulses, including their topology, propagation dynamics, and light-matter interactions.

## 10:10–10:40: Coffee Break

## WED-2: Session 2

Chaired by Cesare Soci - Nanyang Technological University - Singapore

Time: Wednesday, 10:40–12:20

Location: Sala Crati

**Invited**

WED-2.1 10:40

**Onsager Computing– Optimization by the Principle of Minimum Heat Generation** — •ELI YABLONOVITCH and SRI VADLAMANI — Electrical Engineering and Computer Sciences Dept., University of California, Berkeley, CA, USA

Physics itself, performs optimizations in the normal course of dynamical evolution. Nature provides us with the Principle of Least Action, among many other optimization principles. Recently, there has been great success with Onsager Computing using the Principle of Minimum Entropy Generation. Physics can provide machines which solve digital optimization problems much faster than any digital computer. Electrical Onsager Computers run ~10000 times faster have ~10000 times less energy-to-solution, than conventional machines.

**Invited**

WED-2.2 11:00

**Quantum Optics in Room Temperature Quantum Dot Optical Gain Media** — •GADI EISENSTEIN — Technion - Institute of Technology, Haifa, Israël

Quantum coherent light matter interactions occur in room temperature quantum dot based optical gain media by employing 100-200 fs wide excitation pulses which are significantly shorter than the coherence time. Coherently controlled Rabi oscillations, Ramsey fringes, photon. Echoes and coherent revival were demonstrated in a quantum dot optical amplifier operating at 1550 nm.

**Invited**

WED-2.3 11:20

**Spin-orbit interactions in nanophotonics** — •ANATOLY ZAYATS — King's College London, London, United Kingdom

Spin-orbit coupling in evanescent waves results in complex topological vector field structures and influences nonlinear optical interactions, optical forces and is important for high-resolution imaging and metrology. This coupling is mediated by the transverse spin carried by evanescent waves and depends on the presence of orbital angular momentum of the field. In this talk, we will overview optical spin-orbit coupling effects in waveguides and metamaterials, their topological manifestations and applications.

**Invited**

WED-2.4 11:40

**Monolithic BIC metasurfaces in halide perovskites** — •GIORGIO ADAMO — Centre for Disruptive Photonic Technologies, Nanyang Technological University, Singapore

Halide perovskites are a rapidly emerging class of solution processed semiconductors with strong excitonic properties and high refractive index, which make them an ideal platform for light-emitting dielectric metasurfaces. We provide examples of functional monolithic perovskite metasurfaces based on boundary states in the continuum (BIC) including a microlaser with tunable polarization singularities, an inversion symmetry broken metasurface with optical Rashba effect, and their integration into electrically-driven light-emitting devices.

**Invited**

WED-2.5 12:00

**Time interfaces** — •ANDREA ALU — CUNY Advanced Science Research Center

In this work I discuss the observation of photonic time-reflections and associated broadband frequency translations in a switched transmission-line metamaterial whose effective capacitance is homogeneously and abruptly changed via a synchronized array of switches. A pair of temporal interfaces are combined to demonstrate time-reflection-induced wave interference, realizing the temporal counterpart of a Fabry-Perot cavity.

## 12:20–16:00: Lunch and Break

## WED-3: Session 3

Chaired by Amos Martinez Garcia - Nature Materials, Cambridge - UK

Time: Wednesday, 16:00–17:20

Location: Sala Crati

## Invited

WED-3.1 16:00

**Quantum effects in trans-luminal metamaterials: photon conservation, negative refraction, and Hawking radiation** — •JOHN PENDRY<sup>1</sup>, EMANUELE GALIFFI<sup>2</sup>, and PALOMA ARROYO HUIDOBRO<sup>3</sup> — <sup>1</sup>Imperial College London, London, SW7 2AZ, UK — <sup>2</sup>Advanced Science Research Center, City University of New York, 85 St. Nicholas Terrace, 10031 New York, NY, USA — <sup>3</sup>Instituto de Telecomunicações, Instituto Superior Tecnico-University of Lisbon, Avenida Rovisco Pais 1, Lisboa, 1049-001 Portugal.

Structures which appear to move at or near the velocity of light contain singular points. Energy generated by the motion accumulates at these points and we show that the number of photons is conserved. We present both a classical proof and a more formal QED proof demonstrating the absence of unpaired creation and annihilation operators. Exceptions to this rule are found when negative frequencies make an appearance.

## Invited

WED-3.2 16:20

**Electrochemical photonics: tuning functionalities of optical metamaterials in real time** — •ALEXEI KORNYSHEV — Department of Chemistry, Faculty of Natural Sciences, Imperial College London, United Kingdom

This talk will be about a new route to creation of in-real-time-electrotuneable metamaterials, based on a marriage between photonics and electrochemistry. Electrochemistry underpins many branches of science and technology – energy storage/conversion, electrolysis, desalination, electro-deposition/catalysis/actuation/sensing – all based on effects of electric field localised in nm-thin regions at electrode/electrolyte interfaces. Such effects can be used for voltage(<1V)-controlled self-assembly of plasmonic-nanoparticles onto transparent or reflective interfaces, dramatically changing their optical response.

## Invited

WED-3.3 16:40

**Exotic complex-media effects in simpler media** — MOHAMMAD SAJJAD MIRMOOSA, XUCHEN WANG, LUKAS FRETER, ARI SIHVOLA, CONSTANTIN SIMOVSKI, and •SERGEI TRETYAKOV — Aalto University, Espoo, Finland

Generalized duality transformations significantly modify the constitutive relations of electromagnetic media, preserving some electromagnetic properties. Here, we contemplate a transformation of Tellegen nihility as a particular type of extreme-property nonreciprocal bi-isotropic media and show that some intriguing electromagnetic properties of that medium can be realized in particular simpler magnetodielectric media.

## Invited

WED-3.4 17:00

**Self-oscillations in non-Foster and time-varying meta-structures and applications in antenna technology** — •SILVIO HRABAR — University of Zagreb, Faculty of Electrical Engineering and Computing, Zagreb, Croatia

It is shown that the inherent instability of non-Foster artificial electromagnetic structures, usually considered a very serious drawback, can be used for the construction of perfectly-matched and broadly-tunable self-oscillating antennas with injection-locking capabilities. This approach is further extended to unstable time-varying non-Foster structures, allowing additional features such as frequency conversion. The proposed ideas have been verified by measurements on RF experimental demonstrators developed at University of Zagreb.

## 17:20–17:40: Coffee Break

## WED-4: Session 4

Chaired by Rachel Won - Nature Publishing Group, London - UK

Time: Wednesday, 17:40–19:20

Location: Sala Crati

**Invited**

WED-4.1 17:40

**Metamaterials for controlling and generating circular polarization** — KUNIAKI KONISHI and •MAKOTO KUWATA-GONOKAMI — The University of Tokyo, Tokyo, Japan

We report on studies of metamaterials for controlling and generating circularly polarized light. We designed chiral metamaterials with very large optical activity, and we demonstrated tunable and emission polarization control. We also report on circularly polarized harmonic generation utilizing nonlinear metamaterials with discrete rotational symmetry. Such metamaterials should be useful for circular polarization generation and spectroscopy in the vacuum ultraviolet region.

**Invited**

WED-4.2 18:00

**Ultrafast molecular chirality: twisting light to twist electrons** — •OLGA SMIRNOVA — Max-Born Inst. & Technische Univ. Berlin

I will describe several new, extremely efficient approaches to chiral discrimination and enantio-sensitive molecular manipulation based on (i) the new concept of synthetic chiral light—light chiral already in the electric dipole approximation, (ii) chiral topological light, – light that combines local chiral properties with global topological properties, (iii) the new concept of geometric magnetism in photoionization of chiral molecules, leading to new classes of enantiosensitive observables in photoionization.

**Invited**

WED-4.3 18:20

**Anomalous dispersion of surface plasmon polaritons (SPPs) in ultra-strong coupling regime** — MD G. R. CHOWDHURY, SHAMAAR HOWARD, KANIJ M. KHABIR, and •MIKHAIL A. NOGINOV — Center for Materials Research, Norfolk State University, Norfolk, VA 23504 USA

We have studied dispersion of surface plasmon polaritons (SPPs) in the Kretschmann's geometry (prism/Ag/dye-doped polymer) in weak, intermediate, and very strong exciton-plasmon coupling regimes. The dispersion curves obtained in the reflection experiment, were in a good agreement with simple model predictions at small concentrations of the dye (R6G) in the polymer (PMMA). At the same time, highly unusual multi-segment ladder-like dispersion curves were observed at ultra-large dye concentrations

**Invited**

WED-4.4 18:40

**Terahertz topological devices for 6G communications** — •RANJAN SINGH — Nanyang Technological University (NTU), Singapore

The existing 5G communication architecture cannot fulfill present data demands due to bandwidth scarcity, which has stimulated innovative technologies with a vision of 6G communication. Terahertz technologies have been identified as a critical candidate for the emerging 6G communication with the potential to provide ubiquitous connectivity and remove the barrier between physical, digital, and biological worlds.

**Invited**

WED-4.5 19:00

**The future of science publishing** — •OLIVER GRAYDON — Nature Photonics, London, UK

The latest trends and innovations in science publishing will be discussed. Topics to be covered include the evolution of journals in the optics sector, the rise of open access, experiments with peer review, the emergence of open data and code and hints at what lies ahead in the future.

**20:30–22:30: Dinner and discussion theme: What will our research be in 10 years from now?**

## THU-1: Session 1

Chaired by Dennis Couwenberg - Nanophotonics, Amsterdam - The Netherlands

Time: Thursday, 8:50–10:10

Location: Sala Crati

**Invited**

THU-1.1 8:50

**Three recent superoscillations** — •MICHAEL BERRY — University of Bristol

(1) In the Madelung-Bohm representation, the orthogonal trajectories of wavefronts obey Newton's ray equations, augmented by a 'quantum potential', whose vanishing separates regions that are superoscillatory from regions that are not. (2) Superoscillations might seem to violate Heisenberg's uncertainty principle; demonstrating that they do not involves extensions beyond Heisenberg's, and windowing. (3) Generalisation: beyond bandlimited functions, to include places where the phase gradient (local wavevector) exceeds the classically allowed momentum.

**Invited**

THU-1.2 9:10

**Lightwave electronics in trivial and strongly correlated solids** — •MIKHAIL IVANOV — Max-Born-Institut, Berlin, Germany; Humboldt Universität zu Berlin, Germany; Imperial College London, UK

Light pulses shaped on the time-scale of individual oscillations of the electric field open unique opportunities in controlling the electron motion in solids at the single-femtosecond time scale. I will review our recent results on sub-cycle control of electron dynamics in various solids, from trivial to strongly correlated.

**Invited**

THU-1.3 9:30

**Expanding photonics palette: A quest for higher refractive indices** — •JACOB KHURGIN — Johns Hopkins University, Baltimore USA

Photonic community has recently been heavily invested in exotic concepts portending a grand future, fame and fortune. Being a contrarian, I humbly entertain the possibility that simply increasing the refractive index by a modest factor may have a far greater payoff. I explore why higher index materials have not yet materialized and point out a few tentative directions for the search of these elusive materials, be they natural or artificial.

**Invited**

THU-1.4 9:50

**Structured Photons – Their Application in Quantum Photonics** — •EBRAHIM KARIMI — University of Ottawa, Ottawa, Canada

The recent progress, challenges, and applications of structured photons in modern photonics, such as the generation of polychromatic structured photons, structured XUV photons, and their interaction with materials be the subject of my talk. Finally, I will discuss their applications in high-dimensional quantum communication, e.g., free-space, underwater, fibre and curved spacetime links and their security analysis.

## 10:10–10:40: Coffee Break



## THU-2: Session 2

Chaired by Dennis Couwenberg - Nanophotonics, Amsterdam - The Netherlands

Time: Thursday, 10:40–12:20

Location: Sala Crati

**Invited**

THU-2.1 10:40

**Are hollow-core fibres the ultimate metamaterial application?** — •DAVID PAYNE — University of Southampton, Southampton, United Kingdom

Optical fibres having a simple core and cladding form the basis of the global Internet. Until recently they were the ultimate high-capacity information conduit. But is there something better? We are now able to use air as the transmission medium with guidance provided by a carefully structured metamaterial in the fibre cladding. This provides all the advantages of solid fibres, but without the limitations associated with the core glass.

**Invited**

THU-2.2 11:00

**Nanomechanical photonic metamaterials** — •ERIC PLUM — Optoelectronics Research Centre, University of Southampton, UK

An overview over nanomembrane-based nanomechanical photonic metamaterials will be given, from the demonstration of a temperature-actuated metamaterial in 2011 to recent breakthroughs. These include the optical detection of thermal motion in nanomechanical metamaterials, and demonstrations of nanobolometers with record-breaking spatial resolution, electrogyration a million times stronger than in natural materials, nonlinear asymmetric transmission and an optically bistable device at microwatt power levels.

**Invited**

THU-2.3 11:20

**Superoscillation and Super-resolution** — •KEVIN MACDONALD — University of Southampton, UK

Rapid variations of intensity and phase can take place in complex, structured light fields at (sub)nanometre length scales far smaller than the commonly understood half-wavelength ( $\lambda/2$ ) diffraction limit. Such fields, and their interactions with matter also structured at the nanoscale, offer important potential applications in imaging, spectroscopy, metrology, and opto-electronic/mechanical nanodevices, and in fundamental studies of light-matter interaction down to the pico- (i.e. atomic) scale.

**Invited**

THU-2.4 11:40

**Topological plasmonics: Ultrafast vector movies of plasmonic skyrmions on the nanoscale** — •HARALD GIESSEN — 4th Physics Institute, University of Stuttgart, Germany

We introduce a new technique, time-resolved vector microscopy, enabling us to compose entire movies on a sub-femtosecond time scale and a 10 nm scale of the electric field vectors of surface plasmon polaritons. Depending on shape and geometrical phase, in combination with the helicity of the excitation beam, topological plasmonic quasiparticles are created: skyrmions, merons, as well as quasicrystalline excitations. We observe their complete field vector dynamics at subfemtosecond time resolution.

**Invited**

THU-2.5 12:00

**Topological insulator metamaterials** — •CESARE SOCI — Nanyang Technological University, Singapore

Confinement of electromagnetic fields at the subwavelength scale can be used to engineer light-matter interaction in topological insulator crystals and access nontrivial features of their electronic band structure. I will discuss the excitation of spin-selective Dirac plasmons, dielectric resonances and circular photogalvanic currents in nanostructured topological insulator metamaterials across the visible to infrared, and how this could provide new ways to bridge the gaps between nanophotonic, electronic and spintronic technologies.

## 12:20–16:00: Lunch and Break

## THU-3: Session 3

Chaired by Pino Strangi - Case Western Reserve University, Cleveland - USA

Time: Thursday, 16:00–17:20

Location: Sala Crati

**Invited**

THU-3.1 16:00

**Photonic Time-Crystals** — •MORDECHAI SEGEV, ERAN LUSTIG, ALEX DIKOPOLTSEV, MARK LYUBAROV, YAAKOV LUMER, YONATAN SHARABI, and OHAD SEGAL — TECHNION - Israel Institute of Technology

Photonic Time Crystals (PTCs) are dielectric media whose refractive index is strongly modulated periodically in time at rates of an optical cycle. These systems conserve momentum but not energy, and display momentum bands and bandgaps where their eigenmodes amplitudes can increase or decrease exponentially. I will introduce the fundamentals of PTCs and present recent results on light emission by classical dipoles, by excited atoms, and by free electrons in PTCs.

**Invited**

THU-3.2 16:20

**Invited talk** — •MARLAN SCULLY — Texas A&M University, College Station, TX, USA**Invited**

THU-3.3 16:40

**A new generation of metasurface antennas** — •STEFANO MACI — University of Siena, Italy

This presentation describes the evolution of MTS antennas. In the first-generation MTSs were essentially uniform in space and realized by periodic printed element. In the second-generation MTS were constructed in such a way to change boundary conditions in space and control the scattered field. Today we are facing a transition to the third-generation where MTSs change boundary conditions in space and time opening new perspectives in 5G communications and beyond.

**Invited**

THU-3.4 17:00

**Some ideas on temporal metamaterials** — •VINCENZO GALDI — University of Sannio, Benevento, Italy

We present some emerging ideas on temporal metamaterials characterized by rapid (periodic or short-pulsed) time modulations of the constitutive parameters. Specifically, we discuss some extensions to time-varying scenarios of well-known concepts and tools utilized in conventional (spatially variant) metamaterials, including effective-medium theory and related nonlocal effects, analog-computing, Herpin equivalence, synthesis of quarter-wave filters and impedance-matching devices.

## 17:20–17:40: Coffee Break

## THU-4: Session 4

Chaired by Pino Strangi - Case Western Reserve University - Cleveland - USA

Time: Thursday, 17:40–18:20

Location: Sala Crati

**Invited**

THU-4.1 17:40

**Optical metamaterials creating high-efficiency photovoltaics** — •ALBERT POLMAN — AMOLF, NWO Institute, Amsterdam, The Netherlands

We present plasmonic and dielectric metasurfaces that enhance the carrier collection efficiency of solar cells. By optimizing the distribution of optical near fields with carrier selective contact layers we enhance open circuit voltage, fill factor and short circuit current in PbS quantum dot, CIGS, CZTS, and ZnP solar cells and create a 33%-efficient III-V/Si tandem solar cell.

**Invited**

THU-4.2 18:00

**Invited talk** — •POLINA BAYVEL — University College London, United Kingdom

## 18:20–19:00: Closing Ceremony

## THU-5: Session 5: Closing Talks

Time: Thursday, 19:00–20:00

Location: Sala Crati

**Invited**

THU-5.1 19:00

**What have I learned from Theodore Metochites, Luca Pacioli and Sergey Akhmanov?** — •NIKOLAY I. ZHELUDEV — University of Southampton, UK; Nanyang Technological University, Singapore

I will explore the role of genetic and academic ancestries in forming the identity of a researcher

**Invited**

THU-5.2 19:30

**Science, Friendship and Collaboration: A personal perspective** — •NADER ENGHETA — University of Pennsylvania, Philadelphia, USA

As scientists we all interact and collaborate with many colleagues and friends from all over the world. This is one of the wonderful features of science and scientific communities. In this brief talk, I will share my personal perspective on how scientific endeavors are enriched by great friendship and collaboration we develop during our careers.

## 20:30–22:30: Dinner and Concert

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