METAMATERIALS'2017

MARSEILLE | 28 AUG > 2 SEPT

11[TH] International Congress

on Engineered Material Platforms for Novel Wave Phenomena

PROGRAM

http://congress2017.metamorphose-vi.org

Organizing Institutions

The **Virtual Institute for Artificial Electromagnetic Materials and Metamaterials, in short the "METAMORPHOSE VI AISBL",** is a non-for-profit International Association, whose purposes are the research, the study and the promotion of artificial electromagnetic materials and metamaterials.
The Association has been established in 2007 by the partners of the FP-6 Network of Excellence "METAMaterials ORganized for radio, millimeter wave, and PHOtonic Superlattice Engineering" - METAMORPHOSE NoE - funded by the European Commission in 2004-2008.
The METAMORPHOSE VI is an active network integrating, managing, and coordinating several researches and spreading activities in the field of Artificial Electromagnetic Materials and Metamaterials. In order to achieve his purposes, the METAMORPHOSE VI AISBL pursues the following activities:

- Integrate, manage, coordinate, and monitor research projects in the field of Artificial Electromagnetic Materials and Metamaterials;
- Spread excellence in this field, in particular, by organizing scientific conferences and creating specialized journals;
- Create and manage research programmes in this field;
- Activate and manage training programmes (including PhD and training programmes for students and industrial partners);
- Provide information on Artificial Electromagnetic Materials and Metamaterials;
- Transfer new technologies in this field to the Industry;
- Offer advice and services related to Artificial Electromagnetic Materials and Metamaterials to industries, producers, distributors, potential users, service suppliers and to the like in Europe and worldwide.

Among the other activities, the Association owns and organizes the Metamaterials Congress Series and the Doctoral Programmes on Metamaterials.

You are welcome to visit the website, send us your comments, and join the Association!

URL address: http://www.metamorphose-vi.org/

Institut Fresnel, was established in 2000 on the Etoile campus (North of Marseille, South of France), to create synergies and join forces in the fields of photonics, electromagnetism and also signal and image processing, and it has gained an international recognition in electromagnetism and metamaterials, nanophotonics and optical components, data processing and random waves and, finally, advanced and living imaging. For instance, researchers at Institut Fresnel have pioneered research in seismic metamaterials in partnership with the Memard civil engineering company.

Institut Fresnel is a research institute operating under the umbrella of Aix-Marseille Université (the largest university in France, with 74,000 students), the Centre National Recherche Scientifique (CNRS) and Centrale Marseille engineering school. Nowadays, the Institut Fresnel hosts almost 200 postgraduate students, researchers and professors, amongst whom eighty-three full-time permanent staff, with an annual income of about 12.6 million euros (including European Research Grants).

Please have a look at our website to find out more about the work of the researchers of Institut Fresnel.

URL address: http://www.fresnel.fr/

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http://congress2017.metamorphose-vi.org

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Metamaterials 2017

Support, Sponsors, Exhibitors

Organizational support

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Metamaterials 2017

Foreword

Filiberto Bilotti,
Geneal Chair

Andrea Alù,
General Co-Chair

It is our great pleasure to welcome you at the *11th Edition of the Metamaterials Congress* in Marseille, France. This event is co-organised by the *Virtual Institute for Artificial Electromagnetic Materials and Metamaterials* (METAMORPHOSE VI) and the Institut Fresnel. Last year we celebrated the 10th Anniversary of the Congress in Crete: it was an occasion for celebration but also to make an assessment of the whole Congress series and plan together the route for the future.

The Congress series, initiated by the *European Network of Excellence METAMORPHOSE* and convened annually by the METAMORPHOSE VI, was originally intended to gather scientists from the engineering and physics communities working on artificial electromagnetic materials and metamaterials. This was also reflected in the sub-title of the Congress: the *International Congress on Advanced Electromagnetic Materials in Microwaves and Optics.* However, it has become evident that the concept of metamaterials has gained a much broader breadth and the Congress, consequently, has been attracting in recent years more and more researchers working in many fields of science and technology, including material science and electromagnetism, physics of solids and acoustics, nanofabrication and chemistry, thermodynamics and mechanics, nano- and quantum-mechanics, civil engineering and device design. To reflect this multidisciplinary nature, after an interesting discussion with eminent scientists and close friends of our community, we have decided to modify the sub-title of the Congress, which has become *International Congress on Engineered Materials Platforms for Novel Wave Phenomena.*

The hope is that the Congress will continue for many years to provide a unique forum for presenting the latest results in the dynamic field of metamaterials and their applications in many fields of science and technology. The Congress traditions, established and nurtured by its long history and predecessors, *International Conferences on Complex Media and Metamaterials (Bianisotropics)* and *Rome International Workshops on Metamaterials and Special Materials for Electromagnetic Applications and TLC,* will be further advanced in Marseille. A balanced mix of plenary, invited, contributed and poster presentations, all subjected to rigorous peer review, encompasses diverse aspects of the fundamental theory, modelling, design, applications, fabrication, and measurements.

The Congress is traditionally accompanied by the European Doctoral School on Metamaterials. This year school is devoted to *modelling of metamaterials: numerical methods and homogenization techniques.*

We would like to thank all our sponsors and colleagues who have helped with the Congress organisation and offered their scientific and technical contributions.

The success of the conference series allows METAMORPHOSE VI, a non-for-profit international association, to provide financial support to a number of participants, particularly students, to operate the European Doctoral Program on Metamaterials (EUPROMETA) and to deliver other services to the broad metamaterials community.

Filiberto Bilotti, Geneal Chair
Andrea Alù, General Co-Chair

Metamaterials 2017
Preface

On behalf of the Technical Program Committee, it is my pleasure to present to you the technical program of Metamaterials'2017, the 11th International Congress on Engineered Material Platforms for Novel Wave Phenomena.

Now more than ten years after the first edition of this conference, originally more focused in microwaves and optics, the metamaterial concept has expanded across fields of expertise and continues to reinvent itself as an enabling technology. This is manifest from our really cross-disciplinary scientific program that in this edition covers a myriad of topics as diverse as acoustics, mechanics, civil engineering, maritime engineering, microwaves, photonics, materials science, nanofabrication techniques, and quantum technology.

This year the scientific sessions are organized in four-parallel tracks of oral talks selected from over 350 submitted articles. The program includes (71) invited and (192) contributed oral presentations. In addition, we have an interactive poster session with 84 presentations, which provides the opportunity for more informal discussions and personal exchanges. I offer my sincere gratitude to all the reviewers who worked very hard to provide insightful and constructive reviews in a timely manner.

The congress highlights are evidently the plenary presentations, and we look forward to listening to the inspiring talks of George Eleftheriades, Mathias Fink, Steven Johnson and Vladimir Shalaev.

We also have two exciting and unique events in the scientific program: the "Physical Reviews Journals Symposium" and the "Nature Research Symposium". These two special sessions are organized by the Editors of the Physical Review journals and by the Editors of the Nature Publishing Group journals, respectively, and promise to draw attention to new developments within and beyond the traditional domain of metamaterials research and discuss the role of metamaterial technology in the "grand challenges" of the 21st century.

In addition, we will host special sessions on commercialization of metamaterials, microwave metamaterials, hydrodynamic metamaterials for maritime engineering, mechanical metamaterials, acoustic metamaterials for noise reduction, and seismic metamaterials.

I am deeply indebted to all the friends and colleagues who helped us to shape the scientific program.

I wish you a wonderful and fruitful stay in Marseille. Enjoy the conference!

Mario Silveirinha,
Chair of the Technical Program Committee

Metamaterials 2017
Welcome message

Sébastien Guenneau

Boris Gralak

Dear Friends and Colleagues,

We are delighted to welcome you in Provence for the 11th edition of The International Congress on Engineered Material Platforms for Novel Wave Phenomena, Metamaterials 2017. The conference takes place in Marseille, capital of Provence, in the South of France. Marseille, or Massalia in ancient greek, was born 2600 years ago of the union of an indigenous princess, Gyptis, with a navigator from Phocaea in Asia Minor, Protis, who was going to create a Greek trading post on the shores of Lacydon, our present Vieux Port. It seems therefore fairly natural to host Metamaterials 2017 in Marseille, after the very successful conference Metamaterials 2016 held in Crete last September. Marseille is a place that not only has a very rich history, but also high quality education and research. Aix-Marseille University (AMU) was founded in 1409 when Louis II of Anjou, Count of Provence, petitioned the Pisan Antipope Alexander V to create the University of Provence, and it currently has 74,000 undergraduate and postgraduate students, 3,000 PhD students and over 8,000 administrative and research and teaching permanent staff, what makes it the largest French University with a total annual budget of 720 million euros. AMU has close collaboration with the French National Centre for Scientific Research (CNRS), which has a total annual budget of 3.3 billion euros and employs 32,000 administrative and research civil servants and the French Atomic Energy and Alternative Energies Commission (CEA). The CEA hosts the ITER project in Provence, for which 35 nations are collaborating to build the world's largest tokamak to prove the feasibility of fusion as a large-scale and carbon-free source of energy. Institut Fresnel (IF), which has ongoing projects on metamaterials with CEA in Paris-Saclay and ITER, is one of the 130 research centers of AMU, and is also operating under authority of CNRS and the Centrale Marseille engineering school. IF was created at the turn of the millennium and it now has 172 members, 83 of whom are permanent administrative, research and teaching staff, 36 are postdocs and 53 PhD students. IF is renowned for its research in metamaterials for control of electromagnetic, hydrodynamic and seismic waves, as well as for research in nanophotonics and optical components, data processing and random waves and advanced and living imaging.

We wish and hope that you will enjoy the conference, you will have the chance to have fruitful discussions with colleagues and friends and to stay updated with the latest important developments in the Metamaterials field not only in electromagnetism, but other wave phenomena.

Moreover, we wish you to enjoy the lectures and the conference time, as well as discover the treasures of Marseille, the **National park of Calanques and the Frioul Archipelago and their lovely beaches.**

Finally, we would like to acknowledge METAMORPHOSE VI, AMU, CNRS, members of Institut Fresnel and all the conference sponsors and supporters. Their contribution to the organization of the conference is invaluable.

Sébastien Guenneau and **Boris Gralak,** Chairs of the Local Committee

Metamaterials 2017
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Metamaterials 2017
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Metamaterials 2017
Location

Marseille

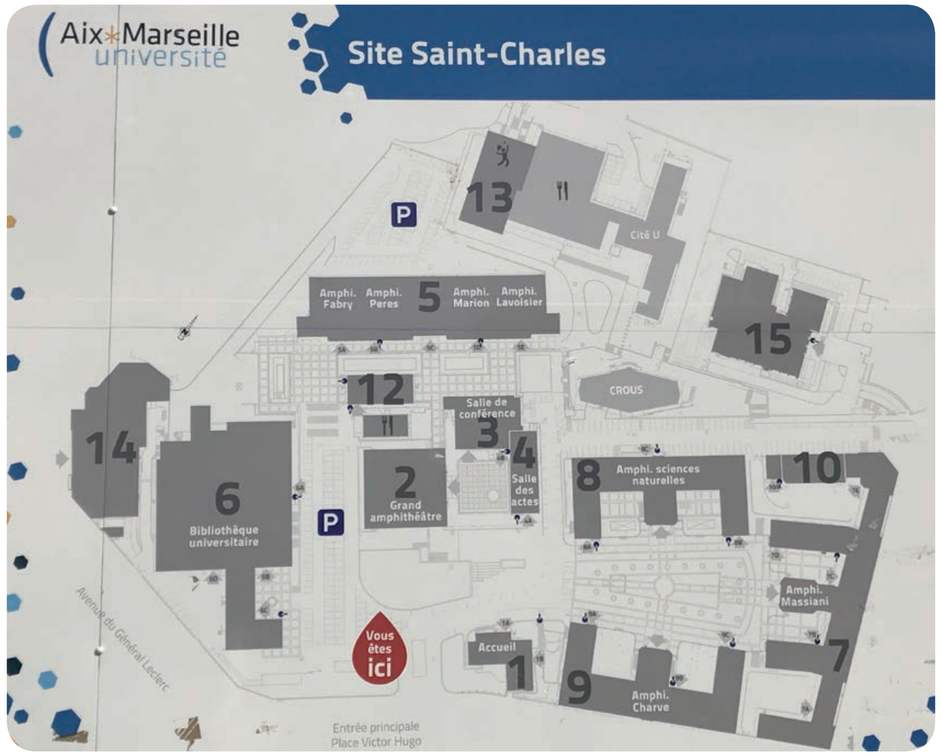
Marseille, or Massalia in ancient greek, was born 2600 years ago of the union of an indigenous princess, Gyptis, with a navigator from Phocaea in Asia Minor, Protis, who was going to create a Greek trading post on the shores of Lacydon, our present Vieux Port. Through this implantation, Massalia contributed to the introduction in Gaul of the culture of the vine and the olive tree, money and writing. It is rapidly emerging as a place of influential exchanges between the Mediterranean and the Celtic world.

Marseille is now France's largest city on the Mediterranean coast and the largest port for commerce, freight and cruise ships. The city was European Capital of Culture, 2013. It hosted the European Football Championship in 2016, and is the European Capital of Sport in 2017.

Metamaterials 2017
Conference Venue

The conference will take place at Aix Marseille University, on Campus Saint Charles, 3 place Victor Hugo, 13003 Marseille, France.

This campus is centrally located, 20 min from the Marignane International Airport **(http://www.marseille-airport.com/)** just next to the main railway station St Charles and in close proximity to the historical center known as Vieux Port (old harbor).



Metamaterials 2017
Social Events

WELCOME RECEPTION

The Welcome reception will take place on Monday 28/08, starting at 18:00 right after the end of the sessions, in the campus St Charles, with a unique opportunity to meet and greet the Physical Review Editors.

We hope to see you all there. Take a chance to enjoy a friendly atmosphere of meeting old friends and creating contacts. Beverages with some apetizers will be served.

CONFERENCE DINNER

The conference dinner will take place at Fort Ganteaume, a historical monument overlooking the hold harbor (Vieux Port), in Marseille on Wednesday, August 30, starting at 19:30. You will have the chance to enjoy and experience local dishes, combined with music.

EXCURSIONS & SOCIAL EVENT

There is the possibility for excursion and guided tours for the accompanying persons.

Excursion from the conference venue can bring you to discover the treasure of Marseille *"National Park of Calanques"*. Simply take Metro line 1 or 2 from St Charles to Castellane station and then take the Bus 21 to Luminy. This is followed by a 20mn walk to reach the sea through a magnificent path in the pine forest. For more information, contact Tourist Office of Marseille.

Moreover, for the conference attendees who will stay on Thursday evening (08-31), there will be a social event consisting of an organized excursion in the Bay of Marseille. Discover the new architecture of Marseille waterfront (MuCEM, CMA-CGM tower, Docks...), fishermen harbours, the Frioul Archipelago... Please note that the boat's trajectory passes nearby the If Castle, where the Count of Monte Cristo was kept prisoner. Refreshments will be served on board.

As an alternative to the boat excursion, the conference participants can take the Little Train to Notre Dame de La Garde, the neo-Byzantine church from the 15th century which overlooks the city.

Contact Welcome Reception for boat and little train guided tours.

Metamaterials 2017
Sessions Matrix

Monday, 28th August

	Grand Amphi Large Theater	SCIENCES NAT Theater	MASSIANI Theater	CHARVE Theater
	Sessions A	Sessions B	Sessions C	Sessions D
08:45 – 09:00	Opening Ceremony			
09:00 – 10:00	Plenary Session I			
10:00 – 10:30	Coffee Break			
10:30 – 12:30	Special Session on Commercialization of Metamaterials	Mechanics I	Metasurfaces I	Nanoantennas
12:30 – 14:00	Lunch Break			
14:00 – 15:30	Special Session on Microwave Metamaterials and Metasurfaces	Thermal Radiation and Effects	Plasmonics	Metamaterials for Antennas
15:30 – 16:00	Coffee Break			
16:00 – 18:00	Physical Review Journals Symposium	Biosensing and Bio Applications	Acoustics I	Topological Effects and Light Spin
18:00 – 19:30	Welcome Reception Meet-and-greet the Physical Review Editors			

Metamaterials 2017
Session Matrix

Tuesday, 29th August

	Grand Amphi large theater	SCIENCES NAT theater	MASSIANI theater	CHARVE theater
	Sessions A	Sessions B	Sessions C	Sessions D
09:00 – 10:00	Plenary Session II			
10:00 – 10:30	Coffee Break			
10:30 – 12:30	Theory and Modelling I	Mechanics II	Active Metamaterials	Metasurfaces for Antennas
12:30 – 14:00	Lunch Break			
14:00 – 15:30	Special Session on Hydrodynamic Metamaterials for Maritime Engineering	Graphene Plasmonics	Topological Materials	Theory and Modelling II
15:30 – 16:00	Coffee Break			
16:00 – 18:00	Nonlinear Effects	Acoustics II	Nature Research Symposium: Metamaterials and Grand Challenges	Cloaking
18:00 – 19:00	Nature Research Symposium: Round Table Discussion			

Metamaterials 2017
Session Matrix

Wednesday, 30th August

	Grand Amphi large theater	SCIENCES NAT theater	MASSIANI theater	CHARVE theater
	Sessions A	Sessions B	Sessions C	Sessions D
09:00 – 10:00	Plenary Session III			
10:00 – 10:30	Coffee Break			
10:30 – 12:30	Special Session on Mechanical Metamaterials	Quantum Plasmonics and Superconducting Metamaterials	Metasurfaces II	Tunable, Reconfigurable and Nonlinear Metamaterials
12:30 – 14:00	Lunch Break			
14:00 – 15:30	Exotic Effects at Microwaves	Optical Metamaterials	Transformation Electromagnetics	Optical Forces
15:30 – 17:30	Coffee Break + Poster Session			
17:30 – 18:30	Theory and Modelling III	Scattering Engineering	Device Applications I	Terahertz Waves
19:30 – 23:30	Gala Dinner			

Metamaterials 2017
Session Matrix

Thursday, 31st August

	Grand Amphi large theater	SCIENCES NAT theater	MASSIANI theater	CHARVE theater
	Sessions A	Sessions B	Sessions C	Sessions D
09:00 – 10:00	Plenary Session IV			
10:00 – 10:30	Coffee Break			
10:30 – 12:30	Special Session on Homogenization	Special Session on Seismic Metamaterials	Special Session on Acoustic Metamaterials for Noise Reduction	Quantum and Extreme Metamaterials
12:30 – 14:00	Lunch Break			
14:00 – 15:30	Experimental techniques, fabrication and characterization of metamaterials	Hyperbolic Metamaterials	Light Trapping	Time Varying Metamaterials
15:30 – 16:00	Coffee Break			
16:00 – 17:30	Absorbers	Device Applications II	Chirality and Bianisotropy	Tunable and Active Metamaterials
17:30 – 18:00	Closing Ceremony			

Metamaterials 2017
Program

Sunday, 27th August

15:00 - 18:00	**SUNDAY REGISTRATION** Café L'Ecomotive, 2 Place des Marseillaises, 13001 Marseille

Monday, 28th August

07:45 - 08:45	**MONDAY REGISTRATION**
08:45- 09:00	**OPENING CEREMONY**
09:00- 10:00	**PLENARY SESSION 1** Session chairperson : Andrea Alu Wave Control with "Time Materials" • Mathias Fink, *Institut Langevin, ESPCI, CNRS, France* Photonic crystals and Metamaterials are made from assemblies of multiple elements usually arranged in repeating patterns at scales of the order or smaller than the wavelengths of the phenomena they influence. Because time and space play a similar role in wave propagation, wave propagation is affected by spatial modulation or by time modulation of the refractive index. Here we emphasize the role of time modulation. We show that sudden changes of the medium properties generate instant wave sources that emerge instantaneously from the entire wavefield and can be used to control wavefield and to revisit the way to create time-reversed waves. Experimental demonstrations of this approach with water waves will be presented and the extension of this concept to acoustic and electromagnetic waves will be discussed. More sophisticated time manipulations can also be studied in order to extend the concept of photonic crystals in the time domain.
10:00 - 10:30	**COFFEE BREAK (MONDAY MORNING)**
10:30 - 12:30	**ORAL SESSIONS (MONDAY MORNING)**

Metamaterials 2017
Program

10:30	SPECIAL SESSION ON COMMERCIALIZATION OF METAMATERIALS Organizers: Romain Fleury; Miguel Navarro-Cia; Christos Argyropoulos Session chairperson: Romain Fleury	MECHANICS I Session chairperson: Martin van Hecke
10:30 - 11:00	**Liquid-crystal Based Reconfigurable Holographic Metamaterial Electronically Scanned Antennas** **Invited oral :** • **Nathan Kundtz,** *kymetacorp, USA* Electronically scanned antennas have historically suffered from a standard set of challenges: Cost, Power Consumption, Size, and Reliability. Despite massive investments these have never been overcome using a Phased Array Antenna architecture. In order to address these problems, we have developed an electronically scanned antenna which uses a liquid crystal modulated, metamaterials-based, reconfigurable holographic approach to beam steering. This approach allows high performance antennas to be produced using LCD television production methods which, in turn, enable applications for ESAs with several orders of magnitude lower power consumption, weight, and cost. In May Kymeta is releasing its first commercial satellite antenna based on this technology. In this talk I will introduce our design approach including the use of liquid crystals for microwave design, discuss manufacturing methods including considerations of thin-film-transistor technology in ESAs, cover achieved performance levels and technological limits, and discuss applications of broad interest.	**Experiments on 3D Micropolar Metamaterials** **Invited oral :** • **Tobias Frenzel,** *Institute of Applied Physics and Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Germany* • **Muamer Kadic,** *Institut FEMTO-ST, CNRS, Université Bourgogne Franche-Comté, France* • **Martin Wegener,** *Institute of Applied Physics and Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Germany* We present our work on designing, fabricating, and characterizing three-dimensional chiral (micropolar) mechanical metamaterials that exhibit a twist upon pushing or pulling on them. The twist can exceed one degree of rotation angle per one percent of axial strain. Results from experiments, calculations for the investigated microstructures, and from an effective-parameter continuum model are in good agreement.
11:00 - 11:30	**Metamaterials Electronically Scanning Array: Design of Imaging Radars for Autonomous Vehicles** **Invited oral :** • **Nathan Landy,** *Echodyne Corp, USA* • **Ioannis Tzanidis,** *Echodyne Corp, USA* • **John Hunt,** *Echodyne Corp, USA* • **Tom Driscoll,** *Echodyne Corp, Duke University, USA* Radar is an exceptional sensing technology, able to provide direct measurement of bearing (Azimuth and Elevation angle), range and velocity (Doppler) in all weather and all conditions. Contemporary radar offerings are largely bifurcated between high-performance high-cost phased-arrays (such as the Active Electronically Scanned Arrays (AESA) favored by military users) and commercial radars which sacrifice substantial performance in pursuit of lower-costs, often relying on slow and bulky mechanical	**Novel Topological Concepts for Reliable Mechanical Wave-guiding** **Invited oral :** • **Sebastian Huber,** *ETH Zurich, Switzerland* We discuss novel concepts for reliable mechanical wave-guiding based an band-topology. Starting from a formal theoretical framework we demonstrate two experimental implementation of these new concepts where we provide evidence for back-scattering free wave-guides that can be arbitrarily deformed without any losses in the energy transfer.

10:30	METASURFACES I Session chairperson: Richard Craster	NANOANTENNAS Session chairperson: Mikhail Lapine
10:30 - 11:00	**Surface plasmons and metasurfaces** **Invited oral :** • **John Pendry,** *Imperial College London, United Kingdom* Metallic surfaces support surface plasmon excitations whose properties are intimately connected to the surface geometry. For example a flat silver surface is an excellent mirror, but the same material with a rough surface is black, reflecting hardly any light. Here we use transformation optics to relate many complex surface structures to a single mother structure. In this way we can classify the spectra of these complex surfaces. Examples will be given of singular structures that harvest light, electron energy loss, van der Waals forces and other properties that are related to the surface plasmon spectrum.	**Mixing colors of light in nonlinear dielectric nanoantennas and metasurfaces** **Invited oral :** • **Mohsen Rahmani,** *Australian National University, Australia* • **Dragomir Neshev,** *Australian National University, Australia* Dielectric nanoantennas and metasurfaces are able to manipulate light wavefronts with highest efficiency, however their potential for enhancing nonlinear interactions remains unexplored. Here we show how ultra-small nanocrystals ordered in a metasurface can enable enhanced light-matter interaction for efficient nonlinear wave-mixing. In particular, we show how designer dielectric metasurfaces can enhance second and third harmonic generation resulting in complete nonlinear control of directionality and polarization state of the harmonics.
11:00 - 11:30	**High-efficiency surface plasmon meta-couplers** **Invited oral :** • **Shulin Sun,** *Fudan University, China* • **Qiong He,** *Fudan University, China* • **Shiyi Xiao,** *Fudan University, China* • **Wujiong Sun,** *Fudan University, China* • **JIngwen Duan,** *Fudan University, China* • **Lei Zhou,** *Fudan University, China* Although surface plasmon polaritons (SPPs) have found numerous applications in photonics, how to efficiently excite them remains a grand challenge. We propose a new mechanism to efficiently couple SPPs with free-space light based on artificial gradient metasurfaces. In this talk, we will describe our serial efforts to realize ultra-thin, flat and subwavelength-sized meta-couplers to achieve SPP excitations with very high efficiencies.	**Hybrid plasmonic and dielectric nanoantennas: nanoscale hot electron chemistry, nonlinear optics, and surface-enhanced sensing** **Invited oral :** • **Stefan Maier,** *Imperial College London, United Kingdom* We demonstrate how controlled emission of hot electrons in plasmonic nanoantennas leads to highly localized nanochemistry. This scheme is utilized for the assembly of hybrid metallic nanoantennas consisting both of top-down fabricated elements, and nanosized colloids. The second part of the talk will show new results for dielectric and hybrid metallic/dielectric antennas, based on Si, Ge and GaP, for highly enhanced harmonic generation and surface-enhanced sensing.

beam-steering methods. In this talk, we present Echodyne's Metamaterial Electronically Scanning Array (MESA) platform – a realization of a dynamic metamaterial surface – which enables beam-steering control on-par with phased-arrays but at drastically reduced Cost Size Weight and Power (C-SWaP). As an introduction to Echodyne's commercialization efforts, we give an overview of the radar market landscape, and look at requirement inputs which drive Echodyne's R&D and product roadmaps. In particular, we focus on the sizeable opportunity for sensors which address the requirements of autonomous vehicles (self-driving cars, UAV-based delivery services, etc), and the need for high-performance radars which operate in cluttered and non-sparse environments. We present test results from one such example, a MESA radar product designed to enable small, low-flying UAS to perform detection and collision avoidance at long range. We also discuss portions of the design cycle utilized for MESA, and present a semi-analytic technique developed in-house for modeling beam-forming and array-factor in dense arrays. This technique, named Floquet Array Synthesis Tool (FAST), mitigates reliance on time-consumptive full-wave simulation, and empowers fast simulation-fabrication-test design cycles that are invaluable in industry.

11:30 - 11:45

Volume Manufacturing and Industrial Applications of Metamaterials: Rolling Lithography, Holography, Laser Filtering and Photovoltaics

Invited oral :

- **Themos Kallos,** *Metamaterial Technologies Inc, Canada*
- **George Palikaras, Metamaterial** *Technologies Inc, Canada*

In this paper we examine different applications of metamaterials in industrial environments. We provide overview of activities in laser filtering and photovoltaics. We also stress the importance of manufacturing metamaterials and metasurfaces in high volume and affordably. Specifically, we focus on the technique of rolling lithography, which can produce nanopatterned surfaces over meter-long lengths.

Active Topological Metamaterials

Invited oral :

- **Vincenzo Vitelli,** *University of Leiden, Physics Department, Netherlands*

Liquids composed of self-propelled particles have been experimentally realized using molecular, colloidal, or macroscopic constituents. These active liquids can flow spontaneously even in the absence of an external drive. Unlike spontaneous active flow, the propagation of density waves in confined active liquids is not well explored. Here, we exploit a mapping between density waves on top of a chiral flow and electrons in a synthetic gauge field to lay out design principles for artificial structures termed topological active metamaterials. We design metamaterials that break time-reversal symmetry using lattices composed of annular channels filled with a spontaneously flowing active liquid. Such active metamaterials support topologically protected sound modes that propagate unidirectionally, without backscattering, along either sample edges or domain walls and despite overdamped particle dynamics. Our work illustrates how parity-symmetry breaking in metamaterial structure combined with microscopic irreversibility of active matter leads to novel functionalities that cannot be achieved using only passive materials.

11:30 - 11:45

Wavefront Rerouting with Super-Grating Metasurfaces

- **Andrea Alu,** *The University of Texas at Austin, USA*
- **Dimitrios Sounas,** *The University of Texas at Austin, USA*
- **Younes Radi,** *The University of Texas at Austin, USA*
- **Hamidreza Chalabi,** *The University of Texas at Austin, USA*

Gradient metasurfaces have received significant attention in the past few years, due to their potential for advanced wave manipulation over a thin surface. Following the first, largely inefficient proposals to pattern the impinging wavefront by nanostructuring a plasmonic metasurface, to date there are several elegant approaches to design metasurfaces that can imprint a pattern of choice to the impinging wavefront with large resolution. These approaches typically consist of discrete implementations of the continuous surface impedance profile ideally required to convert a certain wavefront into the desired one, and they all appear to provide a trade-off between efficiency and complexity. Here, on the contrary, we introduce the concept of super-grating metasurfaces, based on which one can arbitrarily steer an impinging beam with unitary efficiency by relying on specifically tailored asymmetric resonances within each unit cell of a suitably designed periodic grating. Our theory shows that broadband anomalous reflection and transmission does not necessarily require the use of continuous spatial gradients of surface impedance, but they can be achieved by suitably designed periodic arrays of resonant particles with specifically tailored asymmetric responses. In addition to their theoretical importance, these results can be important for the design of efficient metasurfaces based on simple and realizable principles.

Enhancing the electrical generation of surface plasmons polaritons with optical nanoantennas

- **Cheng Zhang,** *Institut d'optique Graduate School, France*
- **Jean-Paul Hugonin,** *Institut d'optique Graduate School, France*
- **Christophe Sauvan,** *Institut d'optique Graduate School, France*
- **Jean-Jacques Greffet,** *Institut d'optique Graduate School, France*

It has been known for a long time that inelastic electron tunneling can generate light emission. Recently, this technique has been used to launch surface plasmons polaritons with a scanning tunneling microscope tip. Unfortunately, the emission process has a very low efficiency (lower than one plasmon per 10000 electrons). In this paper, we theoretically show an enhancement of the surface plasmon excitation process by more than three orders of magnitude in a carefully-designed nanopatch antenna. We analyze the physics of the surface plasmon generation with a modal formalism. Huge enhancement factors can be obtained by controlling the coupling between two different modes of the antenna; one mode with a large density of states has to be coupled with one mode with a large radiative efficiency.

11:45 - 12:00

12:00 - 12:15

The Applied R&D Business and Commercialization of Metamaterials at PARC

Invited oral :

- **Bernard Casse,** *PARC, a Xerox company, USA*
- **Armin Volkel,** *PARC, a Xerox company, USA*

PARC, a Xerox company, is an applied R&D powerhouse with a world-class team of experts, and a long-standing culture of innovation. For the past 4 years, PARC has been developing a portfolio of exciting metamaterial technologies for Global Fortune 500 companies and Government clients. Some of these impactful technologies include passive radiative cooling ("self-cooling" material) for building cooling and automotive applications; electronically scanned array platform for self-driving cars and drones; metasurfaces for enhanced wireless communications; thermal barriers for single-pane windows; RF energy harvesting platform for IoT; micro-Doppler sensors for breathing detection; and peripheral nerves/brain focused magnetic stimulation (FMS) technologies. This year, we're creating a new spinoff called Metawave, a VC-backed start-up company geared at accelerating development of our M-FAST technology for intelligent mobility and 4G MU LTE/5G communications. In my talk, I will give an overview of our innovation/strategic agenda, and our efforts to commercialize metamaterials.

Topological Transport Of Rotational Waves In Mechanical Granular Graphene

- **Li-Yang Zheng,** *LAUM, UMR-CNRS 6613, Le Mans France, France*

Granular crystals are periodic structures of elastic beads arranged in crystal lattices. One important feature of granular crystals is that the interactions between beads take place via central and non-central contact forces, leading to the propagation of rotational and rotational-translational coupled waves in the crystals. Here, we theoretically demonstrate that a mechanical granular graphene, a two-dimensional monolayer honeycomb granular crystal, with Dirac dispersion can exhibit effective spin-orbit coupling. Topologically protected one-way transport of rotational edge waves can be achieved on the interface of two topological granular graphenes. The robustness of the edge waves is confirmed by their spatio-temporal evolution simulations with different defects.

12:15 - 12:30

Spatio-Temporal Phononic Crystals: Tunability, Gain and Non-Reciprocity

- **Daniel Torrent,** *Centre de Recherche Paul Pascal, France*

Phononic crystals are artificial periodic structures which allow the control of mechanical energy in ways that would be impossible to achieve with natural materials. The major drawback in the application of these structures is their passive nature, i.e., the absence of efficient mechanisms for the dynamic

11:45 - 12:00

Highly-transparent all-dielectric metasurfaces with broadband response

- **Sergey Kruk,** *Australian National University, Australia*
- **Lei Wang,** *Australian National University, Australia*
- **Hanzhi Tang,** *Australian National University, Australia*
- **Ben Hopkins,** *Australian National University, Australia*
- **Andrey Miroshnichenko,** *Australian National University, Australia*
- **Tao Li,** *Nanjing University, China*
- **Ivan Kravchenko,** *Oak Ridge National Laboratory, USA*
- **Dragomir Neshev,** *Australian National University, Australia*
- **Yuri Kivshar,** *Australian National University, Australia*

We employ the generalized Huygens principle to design and fabricate highly transparent dielectric metasurfaces for complex wavefront manipulation with 99% polarization conversion and 99% diffraction efficiencies and broadband operation at telecom wavelengths.

Efficient harvesting of hot electrons in gap-plasmon based broadband absorbers for water splitting

- **Wen Dong,** *College of Physics, Optoelectronics and Energy, Soochow University, China*

We experimentally demonstrate that a three-layered nanostructure, consisting of a monolayer gold-nanoparticles and a gold film separated by a TiO2 gap layer (Au-NPs/TiO2/Au-film), is capable of near-completely absorbing light within the whole visible region. We demonstrate that the Au-NPs/TiO2/Au-film device can take advantage of such strong and broadband light absorption to harvest hot electrons arising from gap-plasmon decay and consequently increase the photocurrent generation and improve the photo-electric-chemical water splitting performance under visible irradiation.

12:00 - 12:15

Optical metasurfaces based on plasmonic nanoparticles for anti-reflection coatings and transparent absorbers

- **Alessio Monti,** *Niccolò Cusano University, Italy*
- **Andrea Alù,** *University of Texas at Austin, USA*
- **Alessandro Toscano,** *Roma Tre University, Italy*
- **Filiberto Bilotti,** *Roma Tre University, Italy*

In this contribution, we describe an analytical model for the design of lossless and lossy nanoparticles-based metasurfaces working at a desired frequency of the optical spectrum. To show the versatility of our approach, we exploit it for the design of different innovative devices, such as cloaking-inspired anti-reflection coatings, circuit-analog screens and narrowband optical absorbers that are transparent outside their operation bandwidth. All the theoretical results are checked with full-wave simulations confirming the effectiveness of the analytical findings.

Switchable directional excitation surface plasmon polaritons with dielectric nanoantennas

- **Ivan Sinev,** *ITMO University, Russia*
- **Filipp Komissarenko,** *ITMO University, St. Petersburg Academic University, Russia*
- **Andrey Bogdanov,** *ITMO University, Russia*
- **Mihail Petrov,** *ITMO University, Russia*
- **Kristina Frizyuk,** *ITMO University, Russia*
- **Sergey Makarov,** *ITMO University, Russia*
- **Ivan Mukhin,** *ITMO University, St. Petersburg Academic University, Russia*
- **Anton Samusev,** *ITMO University, Russia*
- **Andrei Lavrinenko,** *ITMO University, Technical University of Denmark, Russia, Denmark*
- **Andrey Miroshnichenko,** *Australian National University, Australia*
- **Ivan Iorsh, ITMO** *University, Russia*

We demonstrate directional launching of surface plasmon polaritons on thin gold film with a single silicon nanosphere. The directivity pattern of the excited surface waves exhibits rapid switching from forward to backward excitation, which is driven by the mutual interference of magnetic and electric dipole moments supported by the dielectric nanoantenna.

12:15 - 12:30

Coupled Slot Metasurfaces With Spoof Glide Symmetry

- **Miguel Camacho,** *University of Exeter, United Kingdom*
- **Alastair P. Hibbins,** *University of Exeter, United Kingdom*
- **Oscar Quevedo-Teruel,** *KTH Royal Institute of Technology, Sweden*

In this paper, it is shown that the desirable properties of glide symmetry can be mimicked in systems that

Unveiling Magnetic and Chiral Nanoscale Properties Using Structured Light and Nanoantennas

- **Jinwei Zeng,** *University of California, Irvine, USA*
- **Mohammad Albooyeh,** *University of California, Irvine, USA*
- **Mahsa Darvishzadeh-Varcheie,** *University of California, Irvine, USA*
- **Mohammad Kamandi,** *University of California, Irvine, USA*

		control of their properties, what inhibits them of being used for a great amount of applications. In this talk, we will show how the extension of the spatial periodicity of the materials to include as well "temporal" periodicity provides phononic crystals of three additional properties: tunability, gain and non-reciprocity. These three properties, if properly combined, can lead to a new set of smart materials for the full control of mechanical energy.
12:30 - 14:00	LUNCH BREAK (MONDAY)	
14:00 - 15:30	ORAL SESSIONS (MONDAY - AFTERNOON 1)	
14:00	**SPECIAL SESSION ON MICROWAVE METAMATERIALS AND METASURFACES** Organizers: Ariel Epstein; Ekaterina Shamonina; Francisco Medina Session chairperson: Ariel Epstein	**THERMAL RADIATION AND EFFECTS** Session chairperson: Igor Nefedov
14:00 - 14:30	**Towards low-profile transmitarrays: Multi-objective tradeoffs of inhomogeneous and anisotropic near-field transforming lenses** Invited oral : • **Sawyer D. Campbell,** *The Pennsylvania State University, USA* • **Eric B. Whiting,** *The Pennsylvania State University, USA* • **Daniel Binion,** *The Pennsylvania State University, USA* • **Pingjuan L. Werner,** *The Pennsylvania State University, USA* • **Douglas H. Werner,** *The Pennsylvania State University, USA* Transmitarray antenna performance is limited by the amplitude and phase uniformity of the illumination source. Horns are a common feed-source for transmitarrays, but require large separation distances in order to provide uniform illumination, thus, limiting the ability to realize low-profile horn-fed transmitarray systems. In order to overcome this challenge, transformation optics inspired lenses can be introduced to redistribute the horn's near field and provide uniform phase and magnitude illumination on the transmitarray within a compact space.	**Tailoring Absorption and Thermal Emission with Metasurfaces** Invited oral : • **Jean-Jacques Greffet,** *Institut d'Optique, France* • **Leo Wojszvzyk,** *Institut d'Optique, France* • **Emilie Sakat,** *Institut d'Optique, France* • **Ioana Doyen,** *Institut d'Optique, France* • **Anne-Lise Coutrot,** *Institut d'Optique, France* • **François Marquier,** *Institut d'Optique, France* We show that a periodic array of hot nanoparticles embedded in resonant plasmonic antennas can produce thermal emission with an effective emissivity approaching unity. This type of design allows to control thermal emission by designing the antennas. We expect to modulate thermal emission at a rate exceeding 10 MHz.

	exhibit reflection symmetry only. This is achieved by balancing the influence of the two sub-lattices in the periodic system. Here, this approach is applied to a pair of identical coupled slots, where notches are periodically introduced to the inner and outer conductors in a configuration where each slot individually possesses glide symmetry. As the complete system does not display glide symmetry, the dispersion has the usual pseudo-plasmonic behavior. However, the properties of glide symmetry can be restored by modifying the relative sizes of the notches in the inner and outer conductors, in order to balance their relative effect. The consequence is to vastly reduce the dispersion of the lowest order mode and the reappearance of degeneracies at the Brillouin zone boundary.	• **Mehdi Veysi,** *University of California, Irvine, USA* • **Mina Hanifeh,** *University of California, Irvine, USA* • **Mohsen Rajaei,** *University of California, Irvine, USA* • **Brian Albee,** *University of California, Irvine, USA* • **Eric Potma,** *University of California, Irvine, USA* • **H. Kumar Wickramasinghe,** *University of California, Irvine, USA* • **Filippo Capolino,** *University of California, Irvine, USA* We propose new schemes of photoinduced magnetic and chiral force microscopy to unveil optical magnetism and chirality of samples at nanoscale by measuring the respective photoinduced forces with scanning probes. Structure light illumination is used in conjunction with nanoantennas to unveil elusive properties of matter.
12:30 - 14:00	LUNCH BREAK (MONDAY)	
14:00 - 15:30	ORAL SESSIONS (MONDAY - AFTERNOON 1)	
14:00	**PLASMONICS** Session chairperson: Boris Lukiyanchuk	**METAMATERIALS FOR ANTENNAS** Session chairperson: Silvio Hrabar
14:00 - 14:30	**Ultra-thin transition plasmonic metal nitrides: tailoring optical response to photonic applications** Invited oral : • **Harsha Reddy,** *Purdue University, USA* • **Deesha Shah,** *Purdue University, USA* • **Nathaniel Kinsey,** *Virginia Commonwealth University, USA* • **Vladimir Shalaev,** *Purdue University, USA* • **Alexandra Boltasseva,** *Purdue University, USA* In ultra-thin plasmonic films, approaching only a few monolayers in thickness, the strong confinement leads to the emergence of quantum phenomena, nonlocal effects and potentially enhanced nonlinearities. Recent developments on growing epitaxial quality, atomically flat, ultra-thin titanium nitride films (< 10 nm) that exhibit very good metallic and plasmonic properties, comparable with their bulk counterparts will be presented.	**Passive and Active Metamaterial-inspired Radiating and Scattering Systems Integrated into Structural Composite Materials** Invited oral : • **Kelvin J. Nicholson,** *Defense Science and Technology Group, Aerospace Division, Australia* • **Kamran Ghorbani,** *RMIT University, Australia* • **Richard W. Ziolkowski,** *University of Technology Sydney, Australia* Several passive and active meta-structures have been successfully integrated into load-bearing high performance aerospace structural composite materials. These include an electrically small, metamaterial-inspired Egyptian Axe Dipole (EAD) antenna; a high impedance ground plane (HIGP) to mitigate any cross talk between adjacent antennas; and passive and active circuits including wide bandwidth and conformal amplifiers, bias-tees, and powered LEDs. Several different manufacturing techniques have been tested and the outcome is a well-defined manufacturing process. These structures enable streamlined aerodynamic functional smart skins.

14:30 - 14:45

Higher Symmetries: A new degree of freedom for the design of periodic structures

Invited oral :

- Oscar Quevedo-Teruel, *KTH Royal Institute of Technology, Sweden*
- Guido Valerio, *Université Pierre et Marie Curie, France*

In this presentation, we will introduce the concept of higher symmetries, including both glide and twist symmetries. We will describe the remarkable properties of higher symmetries, such as their ability to produce both large bandgaps and low dispersive media. Higher-symmetry structures provide a new degree of freedom for the design of periodic structures, and find potential application for bandgap waveguide technology, ultra-wideband flat lenses, and low-dispersive leaky wave antennas.

Transformation Heat Conduction and Fluctuational Electrodynamics: Towards Transformation Thermodynamics

- Ahmed Alwakil, *Institut Fresnel, France*
- Myriam Zerrad, *Institut Fresnel, France*
- Claude Amra, *Institut Fresnel, France*

This theoretical work aims to apply transformation optics to heat conduction in solids and thermal radiation in an unified manner. First, we extend Transformation optics to thermal radiation physics described by fluctuation electrodynamics theory. We show that fluctuation electrodynamics is invariant under transformations of transformation optics, then we integrate this proposed approach with heat conduction by using the temperature field solution of the heat equation under transformation. We believe that such approach paves the way to a complete transformation thermodynamics theory.

14:45 - 15:00

Optimization-Based Design Of Thermal Metamaterials

- Ignacio Peralta, *CIMEC (UNL/CONICET), Argentina*
- Víctor Daniel Fachinotti, *CIMEC (UNL/CONICET), Argentina*

To gain control over the diffusive heat flux in a given domain, one needs to engineer a thermal metamaterial with a specific distribution of the generally anisotropic thermal conductivity throughout the domain. Until now, the appropriate conductivity distribution was usually determined using transformation thermodynamics. By this way, only a few particular cases of heat flux control in simple domains having simple boundary conditions were studied. Thermal metamaterials based on optimization algorithm provide superior properties compared to those using the previous methods. As a more general approach, we propose to define the heat control problem as an optimization problem where we minimize the error in guiding the heat flux in a given way, taking as design variables the parameters that define the variable microstructure of the metamaterial. Anisotropic conductivity is introduced by using a laminate made of layers of two materials with highly different conductivities, the thickness of the layers and their orientation throughout the domain are the current design variables. We numerically demonstrate the ability

14:30 - 14:45

Tunable Epsilon near-zero chalcogenides

- Behrad Gholipour, *Optoelectronics Research centre & Department of Chemistry, University of Southampton, United Kingdom*
- Davide Piccinotti, *Optoelectronics Research centre, University of Southampton, United Kingdom*
- Jin Yao, *Department of Chemistry, University of Southampton, United Kingdom*
- Kevin Macdonald, *Optoelectronics Research centre, University of Southampton, United Kingdom*
- Brian Hayden, *Department of Chemistry, University of Southampton, United Kingdom*
- Nikolay Zheludev, *Optoelectronics Research centre, University of Southampton & Centre for Disruptive Photonic Technologies, School of Physical and Mathematical Sciences & The Photonics Institute, Nanyang Technological University , United Kingdom & Singapore*

The enormous potential of chalcogenides as compositionally-tuneable alternatives to noble metals for plasmonics and 'epsilon-near-zero' (ENZ) photonics can be unlocked using highthroughput materials discovery techniques. Taking advantage of the composition-dependent plasmonic properties of binary and ternary telluride alloys, we show the first amorphous ENZ and plasmonic metasurfaces operating across the UV-VIS spectral range.

3D printed metamaterial based substrates

- Darren Cadman, *Loughborough University, United Kingdom*
- Shiyu Zhang, *Loughborough University, uk*
- William Whittow, *Loughborough University, uk*
- Yiannis Vardaxoglou, *Loughborough University, uk*

This paper presents 3D printed substrates with metallic inclusions all manufactured on a Voxel8 Desktop printer. The printer has dual material extrusion capability with one nozzle for standard fused deposition modelling of polymer filaments while a second nozzle extrudes ambiphillic silver ink. The effective permittivity of a block of extruded polymer (poly-lactic acid (PLA)) is increased with the inclusion of printed silver tiles. Discussed here is the manufacturing process and results from measurements made at X-band frequencies using the Nicolson Ross Weir method. Media link : **www.symeta.co.uk**

14:45 - 15:00

Plasmon-Mediated Electrical and Optical Control of Light Transmitting Hybrid Metal Gratings

- Maxim Gorkunov, *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- Irina Kasyanova, *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- Yulia Draginda, *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- Vladimir Artemov, *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- Mikhail Barnik, *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- Artur Geivandov, *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- Serguei Palto, *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*

Hybrid optical nanostructures composed of metallic nanoslit gratings and functional organic materials are studied. Interdigitated aluminum grating covered

Microwave antenna component based on a topologically protected meta-waveguide for routing LHCP and RHCP signals

- Davide Ramaccia, *"RomaTre" University , Italy*
- Alessandro Toscano, *"RomaTre" University , Italy*
- Filiberto Bilotti, *"RomaTre" University , Italy*

In this contribution, we present an antenna system consisting of a circularly polarized antenna connected to a topologically protected meta-waveguide. The system can route the received circularly polarized signals with opposite handedness towards two different ports. The topologically protected waveguide acts as an ortho-mode transducer for circularly-polarized fields of opposite handedness received by the antenna. It is realized by pulling two periodic arrays of metallic cylinders with opposite bi-anisotropy together. Each array emulates the spin-orbit interaction through bi-anisotropy and acts as a symmetric protected topological (STP-) insulator, but at the interface between the two arrays the structure supports a topologically protected surface wave, which is guided in a preferred direction according to the polarization state of the signal. We present the principle of operation and some preliminary numerical results of a complete system, demonstrating the routing property for circularly-polarized waves.

		to manipulate the heat flux by designing a device that blocks the heat flux at the region surrounded by it while maintaining unchanged the flux outside it (an effect that is known as cloaking). We also present another application example of a device that concentrates the thermal energy to its center without disturbing the temperature profile outside it.
15:00 - 15:15	**Microwave Metasurfaces with Honeycomb Symmetry** Invited oral : • **John Sambles,** *University of Exeter, United Kingdom* • **Yulia Dautova,** *University of Exeter, United Kingdom* • **Alastair Hibbins,** *University of Exeter, United Kingdom* Experimental results are presented of the microwave modes supported on a honeycomb array of metallic rods and also on a simple hexagonal 'Chicken-wire' metallic grid. Both sets of data, which show clear Dirac crossings at K points in reciprocal space, are compared well with modelling.	**Shaping The Spectral And Spatial Emissivity With Plasmonic Nano-Antennas** • **Mathilde Makhsiyan,** *MiNaO - ONERA - The French Aerospace Lab, France* • **Patrick Bouchon,** *MiNaO - ONERA - The French Aerospace Lab, France* • **Julien Jaeck,** *MiNaO - ONERA - The French Aerospace Lab, France* • **Riad Haïdar,** *MiNaO - ONERA - The French Aerospace Lab, France* We experimentally demonstrate a multispectral inhomogeneous metasurface made of a non-periodic set of optical nano-antennas that spatially and spectrally control the emitted light up to the diffraction limit. The juxtaposition of these antennas at the subwavelength scale encodes far field multispectral and polarized images.
15:15 - 15:30		**Thermally Tunable Infrared Metasurfaces** • **David Shrekenhamer,** *Johns Hopkins University Applied Physics Laboratory, USA* We report a computational and experimental study using tunable infrared (IR) metasurfaces to demonstrate amplitude modulation (59%) in reflectance mode. The tuning was achieved through the addition of an active material—germanium telluride (GeTe)--within the unit cell of the metasurface architecture. An applied stimulus (temperature) is used to induce a dielectric change in the active material and subsequent variation in the absorption and reflection properties of the metasurface in the IR. Additionally, we explore the prospect of dynamic opto-thermal switching for the prospect of fast modulation.

	with a nematic liquid crystal is shown to exhibit unprecedentedly fast thresholdless electro-optical switching due to the liquid crystal realignment within a thin surface layer. Coating subwavelength silver slit gratings with Langmuir-Blodgett films of azo-dye compound enables the low-intensity optical control of their extraordinary light transmission by photo-induced optical anisotropy.	
15:00 - 15:15	**Field enhancement in strongly-coupled plasmonic nanocone metamaterials** • **R. Margoth Córdova-Castro,** *King's College London, United Kingdom* • **Alexey V. Krasavin,** *King's College London, United Kingdom* • **Mazhar E. Nasir,** *King's College London, United Kingdom* • **Wayne Dickson,** *King's College London, United Kingdom* • **Anatoly V. Zayats,** *King's College London, United Kingdom* In this paper we investigate the engineered field enhancement and tunable modal dispersion in a plasmonic nanocone metamaterial, which can be fabricated using a new scalable manufacturing procedure by ion etching of Au nanorods.	**Metamaterial enhanced slotted waveguide antenna** • **Inigo Ederra,** *Universidad Pública de Navarra, Spain* This paper demonstrates the enhancement of the radiation performance of a slotted waveguide antenna (SWA) when it is covered with a metasurface. The design of this antenna is presented, along with the comparison with a dielectric covered SWA. This comparison shows that 3 dB gain improvement is achieved when the metasurface is used.
15:15 - 15:30	**Revealing The Influence Of Non-Locality On Plasmonic Systems** • **Armel Pitelet,** *Université Blaise Pascal, Institut Pascal, France* • **Antoine Moreau,** *Université Blaise Pascal, Institut Pascal, France* • **Emmanuel Centeno,** *Université Blaise Pascal, Institut Pascal, France* The key mechanism of applied plasmonic relies on plasmonic guided modes, i.e collective oscillations of the coupled electromagnetic fields and conduction electrons of conducting materials like Surface Plasmons (SP). Due to their characteristic high wave vector, and so small effective wavelength, SP based modes like gap-plasmons, or thin metallic slab modes have the ability to confine and slow down light which give them their utility in sensing, miniaturization, and enhanced light-matters interactions. This short effective wavelength also leads plasmonic modes to be sensitive to the non-local response of metals arising from interaction between free electrons in the jellium. While the trend is towards miniaturization of plasmonic devices, there is actually very few experiment revealing the sensitivity of SP like modes to non-locality. We propose here to give an overview of the structures which should be able to reveal and study non-locality in an experimental way, and so to better assess what are the limitations of the widely spread Drude's model which completly neglect this effect on the optical response of plasmonic devices.	**A Metamaterial-Inspired MR Antenna Independently Tunable at Two Frequencies** • **Anna Hurshkainen,** *ITMO University, Russia* • **Anton Nikulin,** *ITMO University, Russia* • **Stanislav Glybovski,** *ITMO University, Russia* • **Redha Abdeddaim,** *Aix-Marseille Universite, Institut Fresnel, France* • **Christoph Vilmen,** *Aix-Marseille Universite, Center for Magnetic Resonance in Biology and Medicine, France* • **Stefan Enoch,** *Aix-Marseille Universite, Institut Fresnel, France* • **Irina Melchakova,** *ITMO University, Russia* • **Pavel Belov,** *ITMO University, Russia* • **David Bendahan,** *Aix-Marseille Universite, Center for Magnetic Resonance in Biology and Medicine, France* We propose and numerically study a novel antenna design for magnetic resonance imaging and spectroscopy. It is based on a dual-layer periodic structure of thin capacitively loaded wires, inspired by wire medium resonators. The design provides a unique combination of a distributed self-resonant structure and independent tunability at two operational frequencies.

15:30 - 16:00	**COFFEE BREAK (MONDAY AFTERNOON)**	
16:00 - 18:00	**ORAL SESSIONS (MONDAY AFTERNOON 2)**	
16:00	**PHYSICAL REVIEW JOURNALS SYMPOSIUM** Organizers: Julie Kim-Zajonz; Manolis Antonoyiannakis; Ling Miao ; Mu Wang Session chairpersons: Ling Miao; Manolis Antonoyiannakis; Julie Kim-Zajonz; Mu Wang	**BIOSENSING AND BIO APPLICATIONS** Session chairperson: Giuseppe Strangi
16:00 - 16:30	**Strong Coupling Between Surface Plasmon Polaritons and Molecular Vibrations** **Invited oral :** • **Oliver Benson,** *Humboldt-Universitaet zu Berlin, Germany* • **H. Memmi,** *Humboldt-Universitaet zu Berlin, Germany* • **S. Sadofev,** *Humboldt-Universitaet zu Berlin, Germany* • **S. Kalusniak,** *Humboldt-Universitaet zu Berlin, Germany* The confined electromagnetic field near plasmonic nanostructures boosts the strength of light-matter interaction. Novel plasmonic nanostructured material can be utilized for enhanced photon absorption, emission, and collection [1]. Electronic excitations, but also phonons or molecular vibrations couple efficiently to plasmon modes or even hybridize with them. In this presentation, we first introduce heavily doped semiconductor oxides as an interesting plasmonic material [2]. Based on this material platform layered structures with 'tailored' metals and dielectrics can be fabricated. An example is the realization of hyperbolic metamaterials operating at near- and midinfrared frequencies using Ga-doped ZnO and Sn-doped In2O3 as metallic component [3]. The hyperbolic dispersion manifests by occurrence of negative refraction and propagation of light with wave vector values exceeding that of free-space. Control of the doping level allows for systematic adjustment of the frequency range with hyperbolic dispersion from the mid-infrared up to almost one micrometer. When coupling single photon emitters to hyperbolic metamaterials, ideally embedded into them, a dramatic enhancement of spontaneous emission is expected. In a second part, we report on strong coupling of surface plasmon polaritons and molecular vibrations [4]. We consider an organic/inorganic plasmonic hybrid structure consisting of a ketone-based polymer deposited on top of a silver layer. Attenuated-total-reflection spectra of the hybrid reveal an anticrossing in the dispersion relation in vicinity of the carbonyl stretch vibration of the polymer with an energy splitting of upper and lower polariton branch up to 14 meV. The splitting is found to depend on the molecular layer thickness and saturates for Qm-thick films. This new hybrid state holds strong potential for application in chemistry and opto-electronics.	**Detection of Molecule Chirality Based on Plasmonic Nanostructures and Metamaterials** **Invited oral :** • **Xiangdong Zhang,** *Beijing Institute of Technology, China* We report recent researches on the ultrasensitive detection and characterization of chirality of biomolecules using plasmonic nanostructurs and metamaterials. We demonstrate both theoretically and experimentally that molecule-induced giant chiroptical effects can be observed by designing nanostructurs and graphene metamaterials.

15:30 - 16:00	**COFFEE BREAK (MONDAY AFTERNOON)**	
16:00 - 18:00	**ORAL SESSIONS (MONDAY AFTERNOON 2)**	
16:00	**ACOUSTICS I** Session chairperson: Vincent Pagneux	**TOPOLOGICAL EFFECTS AND LIGHT SPIN** Session chairperson: Pavel Ginzburg
16:00 - 16:30	**Tailoring locally resonant metamaterials: from local modifications to metamaterials crystals** • **Nadège kaina,** *Institut Langevin, ESPCI Paris & CNRS, France* • **Fabrice Lemoult,** *Institut Langevin, ESPCI Paris & CNRS, France* • **Simon Yves,** *Institut Langevin, ESPCI Paris & CNRS, France* • **Romain Fleury,** *Laboratory of Wave Engineering, EPFL, Switzerland* • **Thomas Berthelot,** *CEA Saclay, France* • **Mathias Fink,** *Institut Langevin, ESPCI Paris & CNRS, France* • **Geoffroy Lerosey,** *Institut Langevin, ESPCI Paris & CNRS, France* We explain the propagation of waves in locally resonant metamaterials using Fano interferences. This allows us to highlight the importance of multiple scattering even at this deep subwavelength scale. This, in turns, permits to envisage exotic phenomena such as subwavelength control of waves, slow waves, negative refraction with a single negative medium or topological metamaterial crystals.	**Universal Spin-Momentum Locking of Light: Topological vs. Causal Origin** **Invited oral :** • **Zubin Jacob,** *University of Alberta/Purdue University, USA* • **Todd Van Mechelen,** *Purdue University, USA* We show the existence of an inherent handedness (spin) of evanescent-electromagnetic-waves which is fundamentally locked to the direction of propagation (momentum). It is universal and accompanies evanescent waves in total internal reflection, waveguides/fibers and surface-states. We will also discuss the concept of Chern numbers for homogeneous media and how it cannot explain this universal effect as it arises from causality requirements on evanescent waves.

16:30 - 16:45

Nonreciprocal Quantum Optical Devices Based on Chiral Interaction between Atoms and Photons with Transverse Spin

Invited oral :

- **Arno Rauschenbeutel,** *TU Wien - Atominstitut, Austria*

Tightly confined light fields exhibit an inherent link between their local polarization and their propagation direction. Their interaction with emitters therefore features chiral, i.e., propagation-direction-dependent, effects which are interesting both conceptually and for quantum-photonic applications.

On-a-chip Biosensing with Optical Nano-resonators

Invited oral :

- **Romain Quidant,** *ICFO-Institut de Ciències Fotòniques, Spain*
- **O. Yavas,** *ICFO-Institut de Ciències Fot òniques, Spain*
- **J. Garcia Guirado,** *ICFO-Institut de Ciències Fot òniques, Spain*
- **P. Dobosz,** *ICFO-Institut de Ciències Fot òniques, Spain*
- **S. Acimovic,** *ICFO-Institut de Ciències Fot òniques, Spain*
- **V. Sanz Beltran,** *ICFO-Institut de Ciències Fot òniques, Spain*

In this talk we report on our most recent advances in the field of biosensing based on both plasmonic and all dielectric nano-optical resonators. We present different sensing schemes that enable detection in a wide scale range from biomolecules to cells.

16:45 - 17:00

17:00 - 17:15

Invisibility Cloaking Using Pseudomagnetic Field For Photon

Invited oral :

- **Fu Liu,** *TDepartment of Electronics and Nanoengineering, Aalto University, Finland*
- **Simon Horsley,** *Department of Physics and Astronomy, University of Exeter, United Kingdom*
- **Jensen Li,** *School of Physics and Astronomy, University of Birmingham, United Kingdom*

We will discuss a new invisibility cloak that designed with the combination of transformation optics and the pseudomagnetic field for photon. The design method also enables us to design more optical

Enhancement of magnetic resonance imaging with metasurfaces: from concept to human trials

Invited oral :

- **Alena Shchelokova,** *ITMO University, Russia*
- **Rita Schmidt,** *Leiden University Medical Center, The Netherlands*
- **Alexey Slobozhanyuk,** *ITMO University, Russia*
- **Themos Kallos,** *Medical Wireless Sensing Ltd, UK*
- **Andrew Webb,** *Leiden University Medical Center, The Netherlands*
- **Pavel Belov,** *ITMO University, Russia*

Metasurfaces represent a new paradigm in artificial

16:30 - 16:45

On the Design of Perfect Acoustic Metasurfaces

- **Ana Díaz-Rubio,** *Aalto University, Finland*
- **Sergei Tretyakov,** *Aalto University, Finland*

In the paradigm of anomalous reflection and transmission, acoustic metasurfaces based on a linear phase gradient do not provide perfect coupling between the incident plane wave and the desired reflected or transmitted wave. In this paper we introduce a general approach to the synthesis of metasurfaces for full control of transmitted and reflected plane waves and show that ideal performance can be realized. The analysis reveals the physical properties of metasurfaces necessary for the implementation of perfect acoustic metasurfaces.

Topological Spoof Plasmon Polaritons Based On C6-Symmetric Crystalline Metasurfaces

- **Romain Fleury,** *Laboratory of Wave Engineering, Switzerland*
- **Simon Yves,** *Institut Langevin, France*
- **Thomas Berthelot,** *CEA, France*
- **Mathias Fink,** *Institut Langevin, France*
- **Geoffroy Lerosey,** *Institut Langevin, France*

We demonstrate topological surface polaritons that propagate on the surface of a two-dimensional (2D) metamaterial made of a subwavelength periodic arrangement of electromagnetic resonators. Such surface modes are obtained at the boundary between 2D domains of distinct topologies, characterized by non-zero spin-Chern invariants, where a spin degree of freedom is induced by relying on six-fold rotational (C6) crystal symmetry combined with time-reversal symmetry. Experiments are conducted in the microwave regime to corroborate the analytical and numerical predictions. Our proposal enables robust subwavelength guiding of electromagnetic waves on a surface along predefined paths.

16:45 - 17:00

Experimental demonstration of topologically protected efficient sound propagation in acoustic waveguide network

- **Qi Wei,** *Nanjing Normal University, China*
- **Xing-Feng Zhu,** *Nanjing Normal University, China*
- **Jie Yao,** *Nanjing Normal University, China*
- **Da-Jian Wu,** *Nanjing Normal University, China*
- **Xue-Wei Wu,** *Nanjing University, China*
- **Xiao-Jun Liu,** *Nanjing University, China*

We experimentally demonstrate an acoustic anomalous Floquet topological insulator in a waveguide network. The gapless edge states are found in the band gap when the waveguides are strongly coupled. The scheme features simple structure and high-energy throughput, leading to efficient and robust topologically protected sound propagation along the boundary.

Symmetric protected topological meta-waveguide system mimics a microwave circulator without the use of magnets

- **Antonino Tobia,** *RomaTre University, Italy*
- **Davide Ramaccia,** *RomaTre University, Italy*
- **Filiberto Bilotti,** *RomaTre University, Italy*
- **Alessandro Toscano,** *RomaTre University, Italy*

In this contribution, we present a three-port component, based on symmetrically protected topological meta-waveguides, which mimics the routing property of a microwave circulator without the use of magnets. We exploit the ability of the meta-waveguide to guide the input signal in a preferred direction according to its circular polarization state.

17:00 - 17:15

Topological Acoustic Polaritons: Robust Sound Manipulation At The Subwavelength Scale

- **Simon Yves,** *Institut Langevin, France*
- **Romain Fleury,** *École polytechnique fédérale de Lausanne, Switzerland*
- **Fabrice Lemoult,** *Institut Langevin, France*
- **Mathias Fink,** *Institut Langevin, France*
- **Geoffroy Lerosey,** *Institut Langevin, France*

The intriguing concept of topological insulators has recently been transposed from condensed matter to classical wave physics such as the acoustics. However, these phononic topological insulators are inherently wavelength scaled because their physics rely on

Intrinsic Spin-Orbit Coupling of Light at the Nanoscale in Free Space

- **J. Enrique Vázquez-Lozano,** *Valencia Nanophotonics Technology Center (NTC-UPV), Spain*
- **Alejandro Martínez,** *Valencia Nanophotonics Technology Center (NTC-UPV), Spain*

In this work we propose a new perspective in order to unveil the mechanism leading to the spin-orbit de/coupling of light at the nanoscale. Taking into account the factorizability condition of the electromagnetic fields we show, by using the spherical vector wave formalism, that this condition is fulfilled only in the far-field region. On the other side, in the near-field region, amplitude (spin) and phase (orbit) manifest

	devices such as a retroreflector and wavefront rotators with arbitrary rotation angle.	subwavelength structures due to their potential to overcome many challenges typically associated with metamaterials. However, despite the fact that many intriguing functionalities of metasurfaces have been demonstrated as "a proof of the principle", real practical applications of metasurfaces are still missing. One of the potential application of metasurfaces is to magnetic resonance imaging (MRI), where by means of the spatial redistribution of the near field it is possible to strongly increase the scanner sensitivity, signal-to-noise ratio, and image resolution. Here, we stress the importance of metasurfaces for improvement of MRI characteristics and present in vivo results obtained with different types of metasurfaces at high (1.5T) and ultra high (7T) field MR machines.
17:15 - 17:30		
17:30 - 17:45	**Acoustic Metamaterial Configurations Based on Detuned Acoustic Resonators Side-Attached to Waveguides** **Invited oral :** • **Sergey I. Bozhevolnyi,** *Centre for Nano Optics, University of Southern Denmark, Denmark* The use of detuned acoustic resonators (DARs) side-attached to an acoustic waveguide is discussed from the perspective of acoustic metamaterials for the realization of narrow transmission bands with slowdown effects (i.e., the acoustic transparency) and narrow-band absorption by terminated waveguides. Both slow sound propagation in narrow transmission bands and subwavelength-sized narrow-band anechoic waveguide terminations are experimentally demonstrated and adequately described using Helmholtz resonators represented with lamped parameters. The example of efficient suppression of a given acoustic room mode with four Helmholtz resonators is also demonstrated.	**Metamaterial Magnetic Resonance Imaging Endoscope** • **Richard Syms,** *Imperial College London, United Kingdom* • **Evi Kardoulaki,** *Imperial College London, United Kingdom* • **Marc Rea,** *Imperial College London, United Kingdom* • **Simon Taylor-Robinson,** *Imperial College London, United Kingdom* • **Chris Wadsworth,** *Imperial College London, United Kingdom* • **Ian Young,** *Imperial College London, United Kingdom* A prototype metamaterial magnetic resonance imaging endoscope is demonstrated, based on flexible, non-magnetic components and a thin-film magneto-inductive receiver. The receiver can form an image along the entire insertion tube and phantom experiments show a signal-to-noise-ratio advantage over a surface array coil to three times the tube diameter at the tip.

	Bragg interferences. Here, we explain how structural deformations of an acoustic metamaterial, although subwavelength scaled, also induce a topological phase transition.	a complex behavior itself, namely, they appear to be coupled with each other according to the spin-orbit coupling regime.
17:15 - 17:30	**Topological Protected Sound Transmission in Flow-free Acoustic Metamaterial] Lattice** • **Zhiwang Zhang,** *Nanjing Univeristy, China* • **Qi Wei,** *Nanjing Normal University, China* • **Ying Cheng,** *Nanjing Univeristy, China* • **Dajian Wu,** *Nanjing Normal University, China* • **Desheng Ding,** *Southeast University, China* • **Xiaojun Liu,** *Nanjing University, China* In this paper we demonstrate the acoustic pseudospin multipolar states in a flow-free acoustic metamaterial lattice. Topologically protected edge states and reconfigurable topological one-way transmission for sound are demonstrated in the system. These results provide diverse routes to construct novel acoustic topological insulators with versatile applications.	**Coupled Mode Theory for Interaction between a Nanoantenna Array and Orbital Angular Momentum Light** • **Sang Soon Oh,** *Imperial College London, United Kingdom* • **Jamie Fitzgerald,** *Imperial College London, United Kingdom* • **Richard Kerber,** *University of Munster, Germany* • **Doris Reiter,** *Imperial College London, University of Munster, Germany* • **Ortwin Hess,** *Imperial College London, United Kingdom* Based on the coupled mode theory, we develop an anaytical model which explains the relation between orbital angular momentum light and the dark/bright modes of a rotation symmetric nanorod array. The model can describe the phase distribution of electric fields for dark and bright modes and the blue shift of the dark modes for reduced gap width.
17:30 - 17:45	**An Acoustic Metamaterial Crystal With A Graphene-like Dispersion** • **Simon Yves,** *Institut Langevin, France* • **Fabrice Lemoult,** *Institut Langevin, France* • **Mathias Fink,** *Institut Langevin, France* • **Geoffroy Lerosey,** *Institut Langevin, France* Graphene, a honeycomb lattice of carbon atoms ruled by tight-binding interactions, exhibits extraordinary electronic properties, due to the presence of Dirac cones within its band structure. Here we explain how one can induce tight-binding coupling within a locally resonant metamaterial made of Helmholtz resonators (soda cans) and how it allows to obtain an acoustic analogue of graphene.	**Exploiting Topological Singularities of Vortex Fields for Shaping and Rotating the Radiation Pattern of Patch Antennas** • **Mirko Barbuto,** *"Niccolò Cusano" University, Italy* • **Mohammad-Ali Miri,** *University of Texas at Austin, Department of Electrical and Computer Engineering, USA* • **Andrea Alù,** *University of Texas at Austin, Department of Electrical and Computer Engineering, USA* • **Filiberto Bilotti,** *"Roma Tre" University, Department of Engineering, Italy* • **Alessandro Toscano,** *"Roma Tre" University, Department of Engineering, Italy* In this contribution, we explore the generation and manipulation of topological singularities of vortex fields in order to shape and rotate the radiation pattern of patch antennas. We first extend at microwaves a result already obtained at optical frequencies for which, by superimposing a constant background on a vortex field, one can modify at will the position of its phase singularity. Then, we demonstrate how this phenomenon can be exploited to design a patch antenna with a desired radiation pattern with topologically robust properties.

17:45 - 18:00		**Metamaterial MRI-based Surgical Wound Monitor** • **Hanan Kamel,** *Imperial College London, United Kingdom* • **Richard Syms,** *Imperial College London, United Kingdom* • **Evi Kardoulaki,** *Imperial College London, United Kingdom* • **Marc Rea,** *Imperial College London, United Kingdom* An implantable sensor for monitoring wound healing after bowel reconstruction is demonstrated. The sensor consists of a pair of magneto-inductive ring resonators, designed for mounting on a biofragmentable anastomosis ring and inductively coupled to an external coil to give a local increase in signal-to-noise ratio near an annular wound during 1H magnetic resonance imaging. SNR enhancement is confirmed using thin-film prototypes operating at 3T.
18:00 - 18:30	**MEET-AND-GREET THE PHYSICAL REVIEW EDITORS**	
	• **Ling Miao,** *Physical Review X,* • **Julie Kim-Zajonz,** *Physical Review Applied,* • **Manolis Antonoyiannakis,** *Physical Review B,* • **Mu Wang,** *Physical Review Letters* Meet-and-greet the Physical Review Editors	

17:45 - 18:00	**Double Zero Index Acoustic Metamaterial** • **Marc Dubois,** *UC Berkeley, USA* • **Chengzhi Shi,** *UC Berkeley, USA* • **Xuefeng Zhu,** *UC Berkeley, USA* • **Yuan Wang,** *UC Berkeley, USA* • **Xiang Zhang,** *UC Berkeley, USA* Acoustic double zero index metamaterial with simultaneous zero density and infinite bulk modulus induced by Dirac cone at the Brillouin zone center provide a practical solution for applications. The resulted finite impedance of this metamaterial can be designed to match with surrounding materials. However, such metamaterial consists of scatterers with lower sound speed than the matrix, which is fundamentally challenging for air acoustics because the sound speed in air is among the lowest in nature.	**Stokes Nanopolarimeter Based on Spin-Orbit Interaction of Light** • **Alba Espinosa-Soria,** *Universitat Politècnica de València, Spain* • **Francisco J. Rodríguez-Fortuño,** *King's College London, United Kingdom* • **Amadeu Griol,** *Universitat Politècnica de València, Spain* • **Alejandro Martínez,** *Universitat Politècnica de València, Spain* We present a Stokes nanopolarimeter based on spin-orbit interaction of light that allows the instantaneous, non-destructive and local measurement of the polarization of light that impinges on it. The system consists of a subwavelength scatterer placed in close proximity to a multimode waveguide, so that the incoming polarization is mapped into amplitudes of the propagating modes. We also show that the system can be designed to operate optimally and demonstrate it experimentally at telecom wavelengths on a silicon on insulator chip.
18:00 - 18:30	**MEET-AND-GREET THE PHYSICAL REVIEW EDITORS**	
	• **Ling Miao,** *Physical Review X,* • **Julie Kim-Zajonz,** *Physical Review Applied,* • **Manolis Antonoyiannakis,** *Physical Review B,* • **Mu Wang,** *Physical Review Letters* Meet-and-greet the Physical Review Editors	

Tuesday, 29th August

09:00 - 10:00	PLENARY SESSION II	
09:00	PLENARY SESSION II Session chairperson : Filiberto Bilotti	
09:00 - 10:00	**Advances in Huygens' Metasurfaces and Their Applications** • George Eleftheriades, *University of Toronto, Canada* We review the concept of the Huygens' metasurface which comprises co-located electric and magnetic dipoles forming an array of Huygens' sources. These engineered surfaces can be designed to manipulate electromagnetic waves at will. Both passive and active Huygens' metasurfaces can be envisioned.	
10:00 - 10:30	COFFEE BREAK (TUESDAY MORNING)	
10:30 - 12:30	ORAL SESSIONS (TUESDAY MORNING)	
10:30	THEORY AND MODELLING I Session chairperson: Mathias Fink	MECHANICS II Session chairperson: Martin Wegener
10:30 - 10:45	**Egocentric Physics: It's All About Mie** Invited oral : • Brian Stout, *Université Aix-Marseille, Institut Fresnel, France* • Ross McPhedran, *CUDOS, School of Physics, University of Sydney, Australia* We show that the physics of anapole excitations can be accurately described in terms of a quasi-normal mode interpretation of standard Mie theory without recourse to Cartesian coordinate based `toroidal' currents that have previously been used to describe this phenomenon. In this purely Mie theory framework, the anapole behavior arises as a result of a Fano-type interference effect between different quasi-normal modes of the scatterer that effectively eliminate the scattered field in the associated multipole order.	**Combinatorial Design of Mechanical Metamaterials** Invited oral : • Martin van Hecke, *Amolf Amsterdam @ Leiden University, Netherlands* The structural complexity of mechanical metamaterials is limitless, but, in practice, most designs comprise periodic architectures that lead to materials with spatially homogeneous features. Here we introduce a combinatorial strategy for the design of aperiodic, yet frustration-free, mechanical metamaterials that exhibit spatially textured functionalities. We discuss the underlying mapping to spin and combinatorial problems, and show how combinatorial design opens up a new avenue towards mechanical metamaterials with unusual order and machine-like functionalities.

Tuesday, 29th August

09:00 - 10:00	PLENARY SESSION II	
09:00	PLENARY SESSION II Session chairperson : Filiberto Bilotti	
09:00 - 10:00	**Advances in Huygens' Metasurfaces and Their Applications** • George Eleftheriades, *University of Toronto, Canada* We review the concept of the Huygens' metasurface which comprises co-located electric and magnetic dipoles forming an array of Huygens' sources. These engineered surfaces can be designed to manipulate electromagnetic waves at will. Both passive and active Huygens' metasurfaces can be envisioned.	
10:00 - 10:30	COFFEE BREAK (TUESDAY MORNING)	
10:30 - 12:30	ORAL SESSIONS (TUESDAY MORNING)	
10:30	ACTIVE METAMATERIALS Session chairperson: Allan Boardman	METASURFACES FOR ANTENNAS Session chairperson: Vincenzo Galdi
10:30 - 10:45	**Realistic Implementation of Novel Lasers Based on Resonant Dark States** • Sotiris Droulias, *Institute of Electronic Structure and Laser, Foundation for Research and Technology Hellas, Greece* • T. Koschny, *Ames Laboratory and Iowa State University, USA* • C.M. Soukoulis, *Foundation for Research and Technology Hellas & Ames Laboratory* We propose a metamaterial laser system in which the Q factor is controlled independently of the energy storage mechanism and, hence, coupling of the oscillating mode energy to radiation can be tuned at will. The proposed scheme enables simple layer-by-layer fabrication and is examined in implementations that represent realistic experiments.	**Optimizing Information Gathering Capabilities of a Metasurface** Invited oral : • David Smith, *Duke University, USA* • Dan Marks, *Duke University, USA* • Okan Yurduseven, *Duke University, USA* • Mohammadreza Imani, *Duke University, USA* • Jonah Gollub, *Duke University, USA* We consider those aspects of a metasurface that can be optimized for information gathering in the imaging context, considering both dynamic as well as frequency-diverse metasurface apertures.

10:45 - 11:00

11:00 - 11:15

Rayleigh limit of high-index dielectric nanowires

• **Ory Schnitzer,** *Imperial College London, United Kingdom*

We develop an asymptotic theory for resonant scattering from subwavelength high-index dielectric particles. Starting from Maxwell's equations, we apply the method of matched asymptotic expansions between a "near-field" region, scaling with particle size and the wavelength within the dielectric, and an "outer" region, scaling with a relatively larger vacuum wavelength. For cylindrical wires, we find scalings and elementary asymptotic expressions for scattering cross-sections, directivity, and near-field enhancement factors, along with an intuitive physical picture of the near-, outer- and far-field regions. Our results elucidate the properties of the subwavelength Mie resonances supported by high-index dielectric wires. Whereas scattering cross-sections at different resonant frequencies are comparable, near-field amplification varies remarkably between modes.

Dissipative Elastic Metamaterials

Invited oral :

• **Anastasiia Krushynska,** *Department of Physics, University of Turin, Italy*
• **Federico Bosia,** *Department of Physics, University of Turin, Italy*
• **Marco Miniaci,** *Laboratoire Ondes et Milieux Complexes, University of Le Havre, France*
• **Antonio Gliozzi,** *Department of Applied Science and Technology, Polytechnic University of Turin, Italy*
• **Marco Scalerandi,** *Department of Applied Science and Technology, Polytechnic University of Turin, Italy*
• **Nicola Pugno,** *Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy*

This work presents a review of wave propagation properties in dissipative elastic metamaterials including phononic materials and locally resonant metamaterials. We show that the induced dissipative effects are solely governed by the material viscoelasticity and are the same for all metastructures regardless of their composition and wave attenuation mechanisms. The derived conclusions are validated by an excellent agreement with experimental data.

11:15 - 11:30

Super-Resolution Imaging With Pulse Shaping

• **Andrei Rogov,** *Purdue University, USA*
• **Evgeniy Narimanov,** *Purdue University, USA*

We present a new approach to metamaterial-based super-resolution imaging, where optical pulse shaping allows to dramatically reduce the influence of material loss.

10:45 - 11:00

Self-Collimated beams in 2D complex periodic lattices from P- to PT-symmetry

• **Waqas Wasemm Ahmed,** *Universitat Politècnica de Catalunya, Spain*
• **Muriel Botey,** *Universitat Politècnica de Catalunya, Spain*
• **Ramon Herrero,** *Universitat Politècnica de Catalunya, Spain*
• **Kestutis Staliunas,** *Institució Catalana de Recerca i Estudis Avançats (ICREA), Spain*

We analyze self-collimation in two-dimensional P-symmetric and PT-symmetric complex lattices, where the periodic modulations of both refractive index and gain/loss are either in-phase, or dephased a quarter of wavelength of the modulation. Non-diffractive propagation of light beams is analytically predicted and further confirmed by numerical integration of a paraxial model.

11:00 - 11:15

Absorber-Laser Modes And Transparency In The Absense Of PT Symmetry

• **Panayotis Kalozoumis,** *(1) LUNAM Université, Université du Maine, CNRS, LAUM UMR 6613, Av. O. Messiaen, 72085 Le Mans, France, (2) Department of Physics, National and Kapodistrian University of Athens, GR-15771 Athens, Greece, Greece*
• **Christian Morfonios,** *Center for Optical Quantum Technologies, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany, Germany*
• **Fotios Diakonos,** *Department of Physics, National and Kapodistrian University of Athens, GR-15771 Athens, Greece, Greece*
• **Peter Schmelcher,** *(1) Center for Optical Quantum Technologies, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany, (2) The Hamburg Centre for Ultrafast Imaging, Universitat Hamburg, 22761 Hamburg, Germany, Germany*

A systematic approach to the design of non-PT symmetric wave scattering systems possessing multiple coherent perfect absorber (CPA)-laser modes at preselected frequencies is proposed. Under straightforward modifications these systems support the coexistence of unidirectional and bidirectional transparency at the same frequencies.

Shared-Aperture Multibeam Metasurface Antennas

• **David Gonzales Ovejero,** *University of Rennes, France*
• **Gabriele Minatti,** *University of Siena, Italy*
• **Marco Faenzi,** *University of Siena, Italy*
• **Francesco Caminita,** *University of Siena, Italy*
• **Enrica Martini,** *Universtà di Siena, Italy*
• **Stefano Maci,** *University of Siena, Italy*

This paper describes the design multibeam or dual-band antennas using just a single metasurface (MTS) aperture. An example of multi-beam antenna is presented, it is based on a superposition of modulation patterns, and presents a multi-source feeding scheme. The elements of the objective surface impedance tensor are derived in closed-form, and numerical results based on the Method of Moments are presented for validation.

11:15 - 11:30

Fabry-Perot Antenna-transmitter Based on Active Metasurface: One-dimensional Proof-of-concept Demonstrator

• **Borna Vukadinovic,** *University of Zagreb, Croatia*
• **Silvio Hrabar,** *University of Zagreb, Croatia*
• **Josip Loncar,** *University of Zagreb, Croatia*
• **Igor Krois,** *University of Zagreb, Croatia*

The idea of using the unstable non-Foster elements in broadband tunable radiating system has been proposed recently. Here, we present a concept of

Coding Metasurface for Shaping Beams through Software-Based Approach

• **Qian Zhang,** *Southeast university,*

Abstract – We propose a software-based approach to provide an efficient way for designing unit cells based on the optimization algorithm and commercial electromagnetic software. Unit cells are comprised of discretely random lattice, square sub-blocks. The approach combined binary particle swarm optimization (BPSO) and CST Microwave Studio is used to achieve the optimal arrangement of the

11:30 - 11:45

Field Patterns: A New Type Of Wave

Invited oral :

- **Ornella Mattei,** *Department of Mathematics, The University of Utah, USA*
- **Graeme Milton,** *Department of Mathematics, The University of Utah*

Here we introduce the theory of field patterns, which are a new type of wave. Field patterns occur in two-phase space-time microstructures when the microstructure is in some sense commensurate with the speed of the waves in each phase. Rather than an instantaneous disturbance triggering a complicated cascade of disturbances, the disturbances concentrate on a particular pattern: this is the field pattern. Our analysis may also be relevant to the study of the response of microstructured hyperbolic materials in the quasistatic regime.
Media link(s): See arxiv preprint
https://arxiv.org/abs/1611.06257

Strong Localization of Flexural Waves in Disordered Thin Plates

- **Patrick Sebbah,** *CNRS - Institut Langevin & Bar Ilan University, France*
- **Gautier Lefebvre,** *CNRS - Institut Langevin, France*
- **Marc Dubois,** *CNRS - Institut Langevin, France*
- **Etienne Herth,** *CNRS-Femto-ST, France*

We report observation of Anderson localization of bending waves at the surface of a silicon wafer with a random distribution of blind holes. The localized modes are found at frequencies around the hybridization gap opened at the resonance frequency of the blind hole. Modes on each side of the gap are of different nature with different phase relation between the resonators and the plate.

11:45 - 12:00

Bloch Waves in a Triangular Lattice With Tilted Resonators: Applications To Focussing

- **Domenico Tallarico,** *University of Liverpool, United Kingdom*
- **Natalia V. Movchan,** *University of Liverpool, United Kingdom*
- **Alexander B. Movchan,** *University of Liverpool, United Kingdom*
- **Daniel J. Colquitt,** *University of Liverpool, United Kingdom*

We consider a vibrating triangular mass-truss lattice whose unit cell contains a rigid resonator. The resonators are linked by trusses to the triangular lattice nodal points. We assume that the resonator is tilted , \emph{i.e.} it is rigidly rotated with respect to the triangular lattice's unit cell by an angle ϑ_0. This geometric parameter controls a resonant mode in the spectrum for elastic Bloch waves and affects the dispersive properties of the lattice. We provide physical interpretations of these phenomena and discuss the dynamic implications on elastic Bloch waves. In addition, we describe a structured interface containing tilted resonators which exhibits focussing by negative refraction, as in a ``flat elastic lens''.

12:00 - 12:15

A Branch-Cut-Free Tool to Analyze the Wave Propagation in Dispersive Media

- **Mohamed Ismail Abdelrahman,** *Institut Fresnel - Aix-Marseille University, France*
- **Boris Gralak,** *Institut Fresnel - CNRS, France*

The analytical treatment of wave propagation in dispersive media requires handling branch-cuts in

Subwavelength focusing of flexural waves in thin plates

- **Kun Tang,** *Bar Ilan University, Israel*
- **Sébastien Guenneau,** *Aix-Marseille Univ., CNRS, Centrale Marseille, Institut Fresnel, France*
- **Patrick Sebbah,** *Bar Ilan University, Institut Langevin, ESPCI ParisTech, CNRS , Israel, France*

self-oscillating, tunable Fabry-Pérot antenna with active metasurface, and verify it by measurements on 1D experimental demonstrator.

square metal sub-blocks for desirable performance. It is convenient to obtain 1-bit coding elements with the phase difference of 180o over a broad operating frequency band by this method. And based on 1-bit coding elements, we design two coding metasurfaces with single beam and dual beam for specific deflection angle. The proposed method provides a smart tool to realize various functional devices and systems.

11:30 - 11:45

Exceptional Points of Degeneracy in Coupled Modes: Theory and Applications

Invited oral :

- **Mohamed Othman,** *University of California, Irvine, USA*
- **Mehdi Veysi,** *University of California, Irvine, USA*
- **Farshad Yazdi,** *University of California, Irvine, USA*
- **Mohamed Nada,** *University of California, Irvine, USA*
- **Ahmed Abdelshafy,** *University of California, Irvine, USA*
- **Alexander Figotin,** *University of California, Irvine, USA*
- **Filippo Capolino,** *University of California, Irvine, USA*

We explore exceptional points of degeneracies (EPDs) in lossless and in gain-loss balanced waveguides; and we investigate their potential applications in boosting the performance of photonic devices at microwave and optical frequencies.

Metasurface antennas: basic physics, design and synthesis

Invited oral :

- **Gabriele Minatti,** *University of Siena , Italy*
- **Enrica Martini,** *University of Siena , Italy*
- **Stefano Maci,** *University of Siena, Italy*

This paper concerns the analysis of fields and currents on modulated metasurfaces (MTSs) and the synthesis of MTSs implementing a given field distribution. The work herein described has been developed to set up an effective design process for modulated MTSs realizing antennas with customizable pattern. Here we give a brief description of the process for analysis and synthesis of fields in modulated MTSs, in the framework of planar leaky wave antennas. Numerical results are presented for highly directive beam antennas with an aperture efficiency around 75%, for several beam directions.

11:45 - 12:00

12:00 - 12:15

Metamaterial Structures based on 'Negative' Elements: What Do We Know After a Decade of Research ?

Invited oral :

- **Silvio Hrabar,** *University of Zagreb, Croatia*

Almost ten years have passed since the first experimental attempts of enhancing functionality

Investigation of the Drexhage's effect for electrically small dipoles over a flat metasurface

- **Alessio Monti,** *Niccolò Cusano University, Italy*
- **Davide Ramaccia,** *Roma Tre University, Italy*
- **Andrea Alù,** *University of Texas at Austin, USA*
- **Alessandro Toscano,** *Roma Tre University, Italy*
- **Filiberto Bilotti,** *Roma Tre University, Italy*

	the plane of complex frequencies, which significantly complicates the problem. In this contribution, we establish a branch-cut-free analysis, given an arbitrarily dispersive medium with finite dimensions. This approach provides a closed-form expression for the temporal response of dispersive media in terms of discrete poles contributions. Media link(s): See **arXiv:1610.03639v1**	We propose a platonic crystal flat lens capable of superfocusing elastic waves beyond the diffraction limit. The structure of the flat lens is formed by split ring resonators (SRR) arranged in a hexagonal lattice with attached extra layers, perforated in a Duraluminium thin plate. Theoretical studies reveal that the flat lens produces negative refraction of propagating waves and surface states to amplify evanescent waves. Numerical analyses of the superfocusing effect are presented with a point source excitation to the lens.
12:15 - 12:30	**Nonlocal Models For Interface Problems Between Dielectrics And Metals Or Metamaterials** • **Juan Pablo Borthagaray,** *Universidad de Buenos Aires, Argentina* • **Patrick Ciarlet,** *ENSTA Paristech, France* Consider two materials with permittivities/diffusivities of opposite sign, separated by an interface with a corner. When solving the classic (local) models derived from electromagnetics theory, strong singularities may appear. We study here a nonlocal model for scalar problems with sign-changing coefficients. Numerical results indicate that the nonlocal model has some key advantages.	**Pillar-Type Acoustic Metasurface** • **Yabin Jin,** *Institut d'Electronique, de Microélectronique et de Nanotechnologie, UMR CNRS 8520, Université de Lille 1, France* • **Bernard Bonello,** *Institut des NanoSciences de Paris, UMR CNRS 7588, Université Pierre et Marie Curie, France* • **Bahram Djafari-Rouhani,** *Institut d'Electronique, de Microélectronique et de Nanotechnologie, UMR CNRS 8520, Université de Lille 1, France* We theoretically and experimentally investigated the transmission of an anti-symmetric Lamb wave through a single or a line of pillars deposited onto a homogeneous plate when the frequency is tuned to a resonant frequency of the pillars. We show that for either a bending (dipolar) mode or a compressional (monopolar) mode, the resonators emit in the plate a wave 180° out-of-phase with the exciting Lamb wave, resulting in dips in the transmission spectrum. When the bending and compressional resonant frequencies are superposed, the amplitude of the emitted wave exceeds that of the incident wave, which opens the possibility for a new out of phase transmission.
12:30 - 14:00	LUNCH BREAK (TUESDAY)	
14:00 - 15:30	ORAL SESSIONS (TUESDAY - AFTERNOON 1)	
14:00	**SPECIAL SESSION ON HYDRODYNAMIC METAMATERIALS FOR MARITIME ENGINEERING** Organizers: Guillaume Dupont ; Olivier Kimmoun Session chairpersons: Guillaume Dupont ; Olivier Kimmoun	**GRAPHENE PLASMONICS** Session chairperson: Andrei Faraon
14:00 - 14:15	**Water waves near-cloaking of Fano resonance** **Invited oral :** • **T. Bobinski,** *Physique et Mécanique des Milieux Hétérogènes PMMH, France* • **P. Petitjeans,** *Physique et Mécanique des Milieux Hétérogènes PMMH, France* • **A. Maurel,** *Institut Langevin, France*	**Ultrafast and Quantum Phenomena with Graphene Plasmons** **Invited oral :** • **Javier García de Abajo,** *ICFO-Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, Spain*

	of metamaterials by embedment of active 'negative' elements. This paper reviews aforementioned research field, giving an emphasis to unclear issues such as connection between causality, stability, and non-linearity. Finally, some future trends that apply non-linearity and instability of negative elements, are	In this contribution, we investigate the effect of an infinitely-extended reactive metasurface on the complex input impedance of an electrically small dipole placed in its close proximity. We consider, as a reference scenario, the variation of the input resistance and reactance of a vertical (V-) and horizontal (H-) electric dipole placed above a perfect electric conductor for different electrical distances. Then, the perfect electric conductor is replaced by an inductive and a capacitive metasurface. The complex input impedance of the electric dipole is affected by the presence of the metasurface differently compared to the reference scenario. Our preliminary results demonstrate that a control of the input resistance can be achieved by tuning the surface impedance of the metasurface.
12:15 - 12:30		**Enhancing The Performances Of Satellite Telecommunication Systems Exploiting Electromagnetic Cloaking** • **Stefano Vellucci,** *"RomaTre" University, Italy* • **Alessio Monti,** *Niccolò Cusano University, Italy* • **Mirko Barbuto,** *Niccolò Cusano University, Italy* • **Alessandro Toscano,** *"RomaTre" University, Italy* • **Filiberto Bilotti,** *"RomaTre" University, Italy* We exploit electromagnetic cloaking to enhance the performances of the telecommunication system of a nanosatellite platform. We prove that a properly designed mantle cloak can reduce the deteriorating effects introduced by the deployable equipment of a CubeSat-class spacecraft on the link budget between the ground station and the nanosatellite itself.
12:30 - 14:00	LUNCH BREAK (TUESDAY)	
14:00 - 15:30	ORAL SESSIONS (TUESDAY - AFTERNOON 1)	
14:00	**TOPOLOGICAL MATERIALS** Session chairperson: Graeme Milton	**THEORY AND MODELLING II** Session chairperson: Alexander Yakovlev
14:00 - 14:15	**Ultra-singularities of the electromagnetic field in topological materials** • **David E. Fernandes,** *Instituto de Telecomunicações - Universidade de Coimbra, Portugal* • **Mário G. Silveirinha,** *Instituto de Telecomunicações - Instituto Superior Técnico, Portugal* Recently, the ideas of topological photonics were	**Systematic Derivation of Foster-like Circuits for Multiresonant FSSs** **Invited oral :** • **Raul Rodriguez-Berral,** *Dept. Fisica Aplicada 1, Universidad de Sevilla, Spain* • **Francisco Mesa,** *Dept. Fisica Aplicada 1, Universidad de Sevilla, Spain*

	• **Vincent Pagneux,** *Laboratoire d'Acoustique de l'Universit´e du Maine LAUM, France* Locally perturbed waveguides with broken symmetry can be characterized by quasi-trapped modes interacting with the incident propagating wave. This interaction leads to Fano resonances with strong reflection. We show how to cloak such resonance scattering in water wave channels using variable smooth bathymetry.	Optical excitations sustained by atomic-scale materials provide fantastic opportunities to explore novel ultrafast and quantum-optical phenomena, as recently argued in great detail for polaritons in van der Waals materials [1]. Graphene plasmons play a special role among these excitations due to their extraordinay electrical, magnetic, and optical tunability. In this talk, I will review recent advances obatined by my group on the design and realistic description of a new class of random metamaterials incorporating optical gain and displaying a varied photonic behavior ranging from stable lasing to chaotic regimes [2]; a new strategy for molecular sensing that relies on the strong plasmon-driven nonlinearity of nanographenes [3]; a unique scenario in which radiative heat transfer is the fastest cooling mechanism, even beating relaxation to phonons [4]; the generation of intense high harmonics from graphene, assisted by its plasmons [5]; and the possibility of realizing order-one fast light modulation in ultrathin metal-graphene films. I will make emphasis on the potential of these phenomena for the implementation of quantum-optics devices in a robust solid-state environment under ambient conditions.
14:15 - 14:30		
14:30 - 14:45	**Experimental measurements of perfect absorption on surface water waves** • **Eduardo Monsalve,** *ESPCI Paris, France* • **A. Maurel,** *Institut Langevin, France* • **V. Pagneux,** *Laboratoire d'Acoustique de l'Universit´e du Maine LAUM, France* • **P. Petitjeans,** *Physique et Mécanique des Milieux Hétérogènes PMMH, France* We present experimental measurements of perfect wave absorption on surface gravity-capillary waves. The equilibrium between friction losses and coupled resonance yields the reflection coefficient zero. As a simple resonator, among other possibilities, the trapped modes produced by a non-symmetrical cylinder are used to generate absorptiony.	**Drift-induced Spasing in Bilayer Graphene** • **Tiago Morgado,** *Instituto de Telecomunicações and Department of Electrical Engineering, University of Coimbra, Portugal* • **Mário Silveirinha,** *Instituto de Telecomunicações and University of Lisbon, Instituto Superior Técnico, Portugal* We demonstrate that a system formed by two coupled graphene sheets with a drift current may enable pumping graphene plasmons, leading to spasing in the mid-infrared range. This regime relies on exponentially growing wave instabilities that are triggered by drifting electrons streaming through one of the graphene sheets. The nanoscopic characteristic dimensions, together with the wideband tunability, make the proposed structure very attractive to be used as on-chip light source in nanophotonic circuitry.

	extended to a wide class of bianisotropic electromagnetic continua with a spatial cut-off in the material response [Phys. Rev. B, 92, 125153, 2015]. Importantly, conventional material models, for example the permittivity response of a magnetized plasma, are local and hence these materials do not fall precisely into the class of media that can be topologically classified. Here, it is shown that these seemingly limitations of topological photonics in a continuum can enable a giant field concentration and ultra-singularities of the electromagnetic field in a hotspot.</p>	• **Francisco Medina,** *Dept. Electronica y Electromagnetismo, Universidad de Sevilla, Spain* This contribution presents a MoM-based eigenvalue problem to obtain the resonance frequencies and resonant field/current patterns at the elements of a frequency selective surface. Using the resonant patterns as basis functions, simple circuit models with canonical topologies can be systematically extracted.
14:15 - 14:30	**Topological THz Devices using Semiconductors** • **Babak Bahari,** *University of California San Diego, USA* • **Ricardo Tellez-Limon,** *University of California San Diego, USA* • **Boubacar Kante,** *University of California San Diego, USA* We showed that cyclotron resonance of semiconductors can be utilized in Topological devices to break the time-reversal symmetry for unidirectional propagation in THz frequency range. To demonstrate, we proposed a tunable power splitter based on topological effect.	
14:30 - 14:45	**Topological Insulators Based on Coupled Nonlinear Resonators** Invited oral : • **Andrea Alu,** *The University of Texas at Austin, USA* • **Yakir Hadad,** *The University of Texas at Austin, USA* • **Giuseppe D'Aguanno,** *The University of Texas at Austin, USA* • **Alex Khanikaev,** *City College of New York, USA* • **Vincenzo Vitelli,** *Leiden University, Netherlands* The discovery of the topological phase of matter has largely influenced solid state physics, photonics and acoustics research in recent years, offering not only deep physical insights into a new generation of materials and light-matter interactions, but also new engineering tools to tailor signal transport with electrons, light and sound, providing unique features in terms of robustness to defects and disorder. In recent years, we have explored opportunities to enable topologically non-trivial propagation in periodic lattices of resonators based on mechanical motion, spatio-temporal modulation and nonlinearities in the realm of optics and photonics, electromagnetics, acoustics and mechanics. Here we review our recent theoretical and experimental progress in inducing topological transitions in nonlinear arrays of resonators, and triggering the topological nature of their band properties. These transitions are associated with unusual propagation properties, including the insurgence of nonlinear	**Analytical Solution for the Magnetic Coupling of Two Coils Immersed in a Conductive Medium** • **Son Chu,** *University of Oxford, United Kingdom* • **Andrea Vallecchi,** *University of Oxford, United Kingdom* • **Christopher John Stevens,** *University of Oxford, United Kingdom* • **Ekaterina Shamonina,** *University of Oxford, United Kingdom* In the presence of a conductive slab, the mutual inductance of two coupled coils is no longer a real number but becomes a complex quantity whose modulus declines for increasing conductivity and thickness of the slab. In this work, we investigate the case when the two coils are entirely embedded in a conductive medium and derive new analytical formulae for the magnetic vector potential of a coil in a conductive space with dielectric gaps. Our results will have a significant impact on the design and optimisation of magnetoinductive waveguides for underground/underwater communications and embedded biomedical systems.

14:45 - 15:00	**Removable Tsunami Wall Composed of Acoustic Eaton Lens Array** • **Sang-Hoon Kim,** *Mokpo National Maritime University, Korea (South)* A removable tsunami wall made of expandable rubber pillars or balloons of acoustic Eaton lenses is proposed theoretically. The lens creates a stop-band by the rotating the incoming tsunami wave and reduce the pressure by canceling each other. The impedance matching on the border of the lenses results in little reflection. The diameter of each lens is larger than the wavelength of the tsunami near the coast, that is, order of a kilometer. Before a tsunami, the balloons are buried underground in shallow water near the coast in folded or rounded form. Upon sounding of the tsunami alarm, water and air are pumped into the pillars, which expand and erect the wall above the sea level within a few hours. After the tsunami, the water and air are released from the pillars, which are then buried underground for reuse. Electricity is used to power the entire process. A numerical simulation with a linear tsunami model was carried out.	**Plasmon signatures of single molecules near graphene nanoflakes** • **David Zsolt Manrique,** *University College London - EEE, United Kingdom* • **Nicolae Coriolan Panoiu,** *University College London - EEE, United Kingdom* We have computationally investigated quantum plasmon resonance signatures of single molecules on graphene nanoflakes. We have focused on two cases: first we investigated the interactions between a single molecule and a molecular-size graphene nanoflake. Second, we turned our attention to the dimer GNF configuration in which the nanoflakes are linked by a bridging single molecule.
15:00 - 15:15	**Periodic Lattices as a New Type of Dykes** Invited oral : • **G. Dupont,** *Aix Marseille Univ, CNRS, Centrale Marseille, France* • **F. Remy,** *Aix Marseille Univ, CNRS, Centrale Marseille, France* • **O. Kimmoun,** *Aix Marseille Univ, CNRS, Centrale Marseille, France* • **B. Molin,** *Aix Marseille Univ, CNRS, Centrale Marseille, France* • **S. Guenneau,** *Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France* • **S. Enoch,** *Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France* We present a new path to achieve dykes that can attenuate waves associated with storm swell, without affecting coastline in other conditions. The study is built upon works on periodic arrays in the area of metamaterials and more specifically on low frequency band-gaps for which waves cannot propagate in the structures.	**PT Symmetry Breaking In Graphene-Comprising Photonic Devices** • **Dimitrios Chatzidimitriou,** *Aristotle University of Thessaloniki, Greece* • **Alexandros Pitilakis,** *Aristotle University of Thessaloniki, Greece* • **Mmanouil Kriezis,** *Aristotle University of Thessaloniki, Greece* We investigate graphene as a means of probing passive PT Symmetry in a photonic coupler at the telecom wavelength and show that it can be used for the design of switching elements. We present passive PT dynamics, emphasising on properties for a compact/low-loss design, and note appropriate biasing conditions for graphene. Finally, various graphene configurations are investigated to highlight polarisation dependent symmetry breaking.

	solitons guided by moving domain walls, edge modes, and broadband non-reciprocal responses. The emergence of these novel topological states opens the possibility of designing novel electronic, electromagnetic, acoustic and mechanical devices with new functionalities and responses highly tolerant to imperfections in fabrication and disorder, as well as to unwanted parasitic effects.	
14:45 - 15:00		**Material hybrid antennas of meta-atoms for additive manufacturing** • **Yiannis Vardaxoglou,** *Loughborough University, United Kingdom* Dielectric and magnetic properties of meta-atom artificial materials are presented. Their specific effective properties affect the overall performance of small antennas. These structures are manufactured with additive manufacturing and some representative results are shown. Media link: **www.symeta.co.uk**
15:00 - 15:15	**Experiment of Topological cavity modes protected by synthetic Weyl points** • **Hui Liu,** *Nanjing University, China* We construct a synthetic Weyl Points in a parameter space of a photonic crystal. Such Weyl points ensure the existence of the reflection phase vortexes on the surface of a photonic crystal which guarantee the existence of topological cavity modes between the photonic crystals and any other reflecting media.	**Hidden Energy in the Classical Electrodynamics of Dipolar Media** Invited oral : • **Arthur Yaghjian,** *Electromagnetics Research Consultant, USA* It is proven that "hidden energy" is exhibited by permanent Amperian magnetic dipoles rotating in applied fields that makes the total energy supplied to the Amperian dipoles equal to that supplied to magnetic-charge dipoles. This result leads to different expressions for the energy supplied to macroscopic magnetization in diamagnetic and paramagnetic media.

15:15 - 15:30		**Designing Graphene Metasurfaces With Transformation Optics** • Paloma Arroyo Huidobro, *Imperial College London, United Kingdom* Tunable metasurfaces, whose functionality can be dynamically modified, enable ultracompact components with reconfigurable applications. We show how a graphene monolayer subject to a spatially periodic gate bias acts, owing to the surface plasmons supported by the graphene, as a tunable and ultrathin metasurface for terahertz radiation. We use transformation optics to design graphene metasurfaces with unusual mode spectrum, and we apply them to show an isotropic metasurface and an electromagnetic total absorber.
15:30 - 16:00	COFFEE BREAK (TUESDAY AFTERNOON)	
16:00 - 18:00	ORAL SESSIONS (TUESDAY - AFTERNOON 2)	
16:00	**NONLINEAR EFFECTS** Session chairperson: Nikolay Zheludev	**ACOUSTICS II** Session chairperson: Geoffroy Lerosey
16:00 - 16:30	**New horizons for metamaterial-driven temporal solitons and rogue waves** Invited oral : • Allan Boardman, *University of Salford, UK, United Kingdom* • Vladimir Grimalsky, *Autonomous Universiy of State Morelos, Mexico* • Bertrand Kibler, *Universite de Bourgogne, France* • Jim Mcniff, *Original Perspectives, United Kingdom* • Yuriy Rapoport, *Taras Shevchenko National University of Kyiv, Ukraine* New and exciting progress will be presented concerning hyperbolic metamaterial rogue wave generation. This is discussed for the first time. A beautiful, and exciting, list of options for future research and development is revealed.	**The Method Of Matched Asymptotic Expansions For The Accurate Modelling Of Sub Wavelength Resonance In Acoustic Metamaterial Applications** Invited oral : • I. David Abrahams, *Isaac Newton Institute, University of Cambridge, United Kingdom* • William Parnell, *University of Manchester, United Kingdom* The method of matched asymptotic expansions (MAE) has been used to great effect in applied mathematics and particularly in low frequency wave scattering problems. Due to their complexity, low frequency acoustic resonance problems are usually modelled by more simple `equivalent' systems, e.g.\ spring-mass models for the Helmholtz resonator. Here the method of MAE is employed in order to accurately model a wide range of scattering problems where resonance plays a key role. Leading order results reproduce some classical models and higher order corrections allow more complex situations to be analysed and understood. It is anticipated that such models can be of great utility in the field of acoustic metamaterials.

15:15 - 15:30	**Topological Heat Current in a Thermal Equilibrium** • Mario Silveirinha, *University of Lisbon, Portugal* We investigate the role of topological light states in the transport of thermally generated radiation in equilibrium conditions. Remarkably, even when the field fluctuations are purely quantum mechanical, there is a persistent transport of energy in the cavity in closed orbits, rooted in two spatially separated unidirectional topological channels.	
15:30 - 16:00		
16:00 - 18:00	ORAL SESSIONS (TUESDAY - AFTERNOON 2)	
16:00	**NATURE RESEARCH SYMPOSIUM: METAMATERIALS AND GRAND CHALLENGES** Organizers: Lina Persechini ; Maria Maragkou ; Rachel Won Session chairpersons: Lina Persechini ; Maria Maragkou ; Rachel Won	**CLOAKING** Session chairperson: Jonathan Gratus
16:00 - 16:30	**Photonics and Materials Challenges for an Ultralight Laser-Driven Spacecraft for Interstellar Travel** Invited oral : • Harry A. Atwater, *California Institute of Technology, USA* • Artur Davoyan, *California Institute of Technology, USA* • Ognjen Ilic, *California Institute of Technology, USA* • Deep M. Jariwala, *California Institute of Technology, USA* • Michelle C. Sherrott, *California Institute of Technology, USA* • Cora M. Went, *California Institute of Technology, USA* • William Whitney, *California Institute of Technology, USA* • Joeson Wong, *California Institute of Technology, USA* We describe the photonic design and materials characteristics of a laser-driven lightsail which can be accelerated under laser impulse to a velocity v = 0.2c. The sail is designed to be the key building block of a spacecraft capable of interstellar space flight.	**Electromagnetic Cloaking for Antennas** Invited oral : • Mirko Barbuto, *Niccolò Cusano University, Italy* • Alessio Monti, *Niccolò Cusano University, Italy* • Davide Ramaccia, *Roma Tre University, Italy* • Antonino Tobia, *Roma Tre University, Italy* • Stefano Vellucci, *Roma Tre University, Italy* • Andrea Alù, *University of Texas at Austin, USA* • Alessandro Toscano, *Roma Tre University, Italy* • Filiberto Bilotti, *Roma Tre University, Italy* Electromagnetic cloaking represents one of the most fascinating possibilities enabled by metamaterials and metasurfaces. In the last years, cloaking has revealed its potentialities in many realistic applications, ranging from the design of extremely compact TLC platforms up to the compensation of the Doppler effect affecting moving objects. Here, we report some of our results about the use of electromagnetic cloaking for and with antenna systems.

16:30 - 16:45	**Enhancing opto-acoustic properties with metamaterial structuring** • **Mikhail Lapine,** *UTS, Australia* • **M. J. A. Smith,** *UTS, Australia* • **C. Wolff,** *UTS, Australia* • **C. G. Poulton,** *UTS, Australia* • **C. M. de Sterke,** *University of Sydney, Australia* • **B. T. Kuhlmey,** *University of Sydney, Australia* We present our recent results on the design of composite materials for enhanced opto-acoustic interaction. In particular, we report a novel inverse opal structure which allows for simultaneous optical and acoustic confinement in silicon-based waveguides, opening a route towards on-chip stimulated Brillouin scattering. These findings are expected to boost optical applications of non-resonant metamaterials.	**Acoustic Metalens for Subwavelength Resolution Based on Transformation Acoustics** • **Gangyong Song,** *Southeast University, China, China* • **Qiang Cheng,** *Southeast University, China, China* We propose a new approach to design acoustic metematerials lens for subwavelength resolution imaging based on transformation acoustics. The proposed acoustic magnifier creates a virtual high resolution over broadband. The high-resolution imaging property effect is demonstrated numerically from 5650 Hz to 6350 Hz.
16:45 - 17:00	**Tunable Enhancement of Second-Harmonic Generation in Dual Graphene Optical Gratings** • **Jianwei You,** *University College London, United Kingdom* • **Nicolae-Coriolan Panoiu,** *University College London, United Kingdom* Employing geometry dependent plasmon resonances of graphene gratings, we design a graphene bi-layer optical grating, which can achieve several orders of magnitude enhancement of the second-harmonic generation (SHG) intensity. More importantly, this dual grating can act as an ultrafast optical switch as the SHG intensity can be readily controlled via gate voltage tuning.	**Transformation Physics And Homogenization For Cloaking In Plates** • **Lucas Pomot,** *LMA, France* • **Cedric Payan,** *LMA, France* • **Sebastien Guenneau,** *Institut Fresnel, France* We present a time domain analysis of flexural waves propagating in thin plate structured with elliptical perforations. More precisely, we study a one-dimensional invisibility cloak consisting of two anisotropic homogeneous slabs. We use two-scale homogenization techniques to fit the anisotropic parameters obtained by the linear geometric transform with periodic perforations.

16:30 - 16:45	**Flat and conformal optics with dielectric metasurfaces** **Invited oral :** • **Andrei Faraon,** *California Institute of Technology, USA* Flat optical devices based on lithographically patterned sub-wavelength dielectric nano-structures provide precise control over optical wavefronts, and thus promise to revolutionize the field of free-space optics. I discuss our work on high contrast transmitarrays and reflectarrays composed of silicon nano-posts located on top of low index substrates like silica glass or transparent polymers. Complete control of both phase and polarization is achieved at the level of single nano-post, which enables control of the optical wavefront with sub-wavelength spatial resolution. Using this nano-post platform, we demonstrate lenses, waveplates, polarizers, arbitrary beam splitters and holograms. Devices that provide multiple functionalities, like simultaneous polarization beam splitting and focusing are implemented. By embedding the metasurfaces in flexible substrates, conformal optical devices that decouple the geometrical shape and optical function are shown. Multiple flat optical elements are integrated in optical systems such as planar retro-reflectors and Fourier lens systems with applications in ultracompact imaging systems. Applications in microscopy and the prospects for tunable devices are discussed.	**Partial Coherence Uncloaks Diffusive Optical Invisibility Cloaks** • **Andreas Niemeyer,** *Karlsruhe Institut of Technology, Germany* • **Frederik Mayer,** *Karlsruhe Institut of Technology, Germany* • **Andreas Naber,** *Karlsruhe Institut of Technology, Germany* • **Milan Koirala,** *Missouri University of Science and Technology, USA* • **Alexey Yamilov,** *Missouri University of Science and Technology, USA* • **Martin Wegener,** *Karlsruhe Institut of Technology, Germany* Within the range of validity of the stationary diffusion equation, an ideal diffusive-light invisibility cloak can hide arbitrary macroscopic objects. We here show that illumination with partially coherent light under stationary conditions and analysis of the resulting speckle contrast can reveal the cloak.
16:45 - 17:00		**Transformation Based Diffusive-light Cloak for Transient Illumination** • **Bakhtiyar Orazbayev,** *École Polytechnique Fédérale de Lausanne, Switzerland* • **Miguel Beruete,** *Universidad Pública de Navarra, Spain* • **Alejandro Martínez,** *Universitat Politècnica de València, Spain* • **Carlos Garcia-Meca,** *Universitat Politècnica de València, Spain* In this work we design an unidirectional invisibility cloak for a diffusive-light medium based on transformation optics, which provides a broadband, passive and polarization-independent performance and can conceal macroscopic objects. Unlike the other cloaking designs based on scattering cancellation or transformation optics, our design can work under transient illumination, which is crucial in many applications, like time-of-flight imaging or high-speed communication systems. We demonstrate that this technique can also be applied to achieve a multidirectional performance with a polygonal cloak. Moreover, we propose and analyze a simpler design of unidirectional cloak based on a layered stack of two isotropic materials. The performance of the designed cloaks is numerically analyzed in transient regime and the successful concealment of the object is confirmed.

17:00 - 17:15

Perovskite Nanostructures As Meta-Atoms For Mie Resonances Inducing Nonlinear Optical Enhancement

- **Flavia Timpu,** *ETH Zürich, Switzerland*
- **Claude Renaut,** *ETH Zürich, Switzerland*
- **Morgan Trassin,** *ETH Zürich, Switzerland*
- **Manfred Fiebig,** *ETH Zürich, Switzerland*
- **Rachel Grange,** *ETH Zürich, Switzerland*

We measure the linear and the second harmonic generation (SHG) spectra of individual Barium Titanate ($BaTiO_3$) nanostructures. We demonstrate 3 orders of magnitude enhancement of the SHG signal from individual chemically synthesized nanoparticles at the linear Mie resonance compared to an unpatterned layer of $BaTiO_3$. We propose to improve the control of the size and shape of the nanoparticles by using $BaTiO_3$ nanocylinders fabricated by focused ion beam (FIB) milling.

Effective Properties of Phononic Crystals in Bragg Regime

- **Navid Nemati,** *Laboratoire Modélisation et Simulation Multi Echelle, Université Paris-Est, France*
- **Camille Perrot,** *Laboratoire Modélisation et Simulation Multi Echelle, Université Paris-Est, France*
- **Denis Duhamel,** *Laboratoire Navier, Ecole des Ponts, France*
- **Denis Lafarge,** *Laboratoire d'Acoustique de l'Université du Maine, France*
- **Yoonkyung Lee,** *Department of Mechanical Engineering, Massachusetts Institute of Technology, USA*
- **Nicholas Fang,** *Department of Mechanical Engineering, Massachusetts Institute of Technology, USA*

We present how the full account of temporal dispersion and spacial dispersion leads to the precise description of effective-medium parameters of a phononic crystal made of periodic arrangement of rigid inclusions embedded in a viscothermal fluid in high-frequency regime where Bragg scattering phenomena appear. We discuss the interplay between micro-geometry, frequency, fluid motions, and dissipative processes, and its impact on the emergence of macroscopic temporal and spacial dispersion effects. In this respect, we compare the local approach based on a two-scale asymptotic homogenization method, and a general nonlocal homogenization scheme.

17:15 - 17:30

Excitonic Enhancement Of The Transverse Magneto-Optical Kerr Effect In Semiconductor Nanostructures

- **Olga Borovkova,** *Russian Quantum Center, Russia*
- **Felix Spitzer,** *TU Dortmund University, Germany*
- **Ilya Akimov,** *TU Dortmund University, Germany*
- **Vladimir Belotelov,** *Russian Quantum Center, Russia*
- **Maciej Wiater,** *Institute of Physics, Polish Academy of Sciences, Poland*
- **Tomasz Wojtowicz,** *Institute of Physics, Polish Academy of Sciences, Poland*
- **Grzegorz Karczewski,** *Institute of Physics, Polish Academy of Sciences, Poland*
- **Dmitri Yakovlev,** *TU Dortmund University, Germany*
- **Manfred Bayer,** *TU Dortmund University, Germany*

It is demonstrated that the transverse magneto-optical Kerr effect experiences two-order enhancement in the spectral region of the excitonic resonance in the diluted magnetic semiconductor nanostructures. It is studied how the TMOKE depends on the incident angle and extenal magnetic field. The theoretical investigations are in a good agreement with experimental results.

Development of Leaky-Wave Antenna Applications with Acoustics Metamaterials: from the Acoustic Dispersive Prism to Sound Direction Finding with a Single Microphone

- **Hervé Lissek,** *Ecole Polytechnique Fédérale de Lausanne, Switzerland*
- **Hussein Esfahlani,** *Ecole Polytechnique Fédérale de Lausanne, Switzerland*
- **Juan Ramon Mosig,** *Ecole Polytechnique Fédérale de Lausanne, Switzerland*
- **Sami Karkar,** *Ecole Centrale de Lyon, France*

Recent studies have focused on developing metamaterials for acoustic applications, inspired by electromagnetics concepts. The acoustic leaky-wave antenna is amongst the most investigated. Despite the unfavourable properties of conventional matter and structures with respect to sound dispersion and radiation, interesting engineering processes have been recently proposed that are likely to allow such peculiar properties. After presenting the developed one-dimensional leaky-wave antenna design, this paper discusses two pioneering applications of the latter: the Acoustic Dispersive Prism and the Single-Microphone Direction Finding.

17:00 - 17:15

Functional Metamaterials for Biomedical Applications

Invited oral :

- **G. Strangi,** *Case Western Reserve University, USA*
- **K.V. Sreekanth,** *Case Western Reserve University, USA*
- **M. Elkabbash,** *Case Western Reserve University, USA*
- **E. Ilker,** *Case Western Reserve University, USA*
- **M. Hinczewski,** *Case Western Reserve University, USA*
- **U.A. Gurkan,** *Case Western Reserve University, USA*
- **A. De Luca,** *University of Calabria, Italy*
- **N.F. Steinmetz,** *Case Western Reserve University, USA*

In recent years significant efforts have been made to design and fabricate functional nanostructures for biomedical applications and precision medicine. These research activities unlocked a complete new research field known as nano-theranostics, clinical diagnostics and therapies based on nanotechnologies. Optical sensor technology based on plasmonic metamaterials offers significant opportunities in the field of clinical diagnostics, particularly for the detection of lower-molecular-weight biomolecules in highly diluted solutions. On the other hand, many research groups are extensively addressing unmet clinical needs by functionalizing bizarre nanostructures aimed to increase their biocompatibility and to provide them with extraordinary functionalities. Hybrid nano-carriers, viral cargos, organic and inorganic vectors among others represent only a fraction of a large variety of systems proposed to achieve local drug-delivery, photo-thermal and photodynamic therapies, high resolution imaging and stimulated specific immune response to treat and monitor neurodegenerative diseases and cancers. In this context, we have developed a miniaturized plasmonic biosensor platform based on hyperbolic metamaterials supporting highly confined bulk plasmon guided modes that outperform current detection technologies. Upon using a grating technique to couple the optical radiation, different extreme sensitivity modes with a maximum of 30,000 nm per refractive index unit (RIU) and a record figure of merit (FOM) of 590 have been achieved [1-2]. We will also report research activities based on bio-inspired approaches that harness non-toxic viral cargos (plant viruses) functionalized with plasmonic and excitonic materials for longeve intracellular imaging and drug delivery [3-4].

Invisible Random Media And Diffraction Gratings That Don't Diffract

- **Christopher King,** *University of Exeter, United Kingdom*
- **Simon Horsley,** *University of Exeter, United Kingdom*
- **Tom Philbin,** *University of Exeter, United Kingdom*

In this work we discuss ways to mathematically design lossless linear isotropic graded index permittivity profiles in one and two dimensions which suppress scattering. This has some counter-intuitive implications, such as disordered media exhibiting perfect transmission, and periodic gratings which don't diffract.

17:15 - 17:30

Perfect Refraction

- **Martin McCall,** *Imperial College London, United Kingdom*
- **Jonathan Gratus,** *Lancaster University, UK*
- **Paul Kinsler,** *Lancaster University, UK*

The possibility of perfect refraction at an interface is demonstrated via transformation optics. Surprisingly, although all incident angles and polarizations are refracted without reflection, impedance is not matched at the boundary. Expressing both the medium eigen-problem and field continuity at the interface in terms of the field 2-form and the constitutive map, we are able to show that only the transformational approach produces perfect refraction.

17:30 - 17:45	**Nonlinear Optics in Silicon Hybrid Gap Plasmon Waveguides** • Michael P. Nielsen, *Imperial College London, United Kingdom* • Lucas Lafone, *Imperial College London, United Kingdom* • Aliaksandra Rakovich, *Imperial College London, United Kingdom* • Themistoklis P. H. Sidiropoulos, *Imperial College London, United Kingdom* • Stefan A. Maier, *Imperial College London, United Kingdom* • Rupert F. Oulton, *Imperial College London, United Kingdom* We present a new class of silicon hybrid gap plasmon waveguides designed for adiabatic nanofocusing to enhance nonlinear processes in the gap. Using a 3-photon absorption process in quantum dots selectively placed in the metallic, we show a 167326 intensity enhancement for a 24nm wide waveguide. Later we adapt the structure for nonlinear frequency conversion studies using a nonlinear polymer in the gap.	**Broadband absorbing acoustic metamaterials with combined heterogeneous double split hollow sphere (CHDSHS)** • Jungsik Choi, *Hanyang University, Republic of Korea, Korea (South)* • Gilho Yoon, Hanyang University, *Republic of Korea, Korea (South)* The conventional resonace based sound absorbing metamaterials have narrow driving frequencies. In this study, we developed CHDSHS, a metamaterial capable of broadband absorption through a simple structure.
17:45 - 18:00	**Interplay of Magnetic and Electric Nonlinear Responses in AlGaAs Nanoantennas** • Sergey Kruk, *Australian National University, Australia* • Lei Xu, *Australian National University, Australia* • Rocio Camacho-Morales, *Australian National University, Australia* • Mohsen Rahmani, *Australian National University, Australia* • Lei Wang, *Australian National University, Australia* • Daria Smirnova, *Australian National University, Australia* • Guoquan Zhang, *Australian National University, Australia* • Hark Hoe Tan, *Australian National University, Australia* • Chennupati Jagadish, *Australian National University, Australia* • Yuri Kivshar, *Australian National University, Australia* • Dragomir Neshev, *Australian National University, Australia* We suggest and demonstrate experimentally efficient second-harmonic generation with AlGaAs nanoantennas. We show that the harmonic directionality and efficiency are defined by interplay of electric and magnetic multipoles and controlled by incident polarization of light.	**Liquid-Filled Double-Porosity Granular Media: A Novel Class of Phononic Crystals** • Athina Alevizaki, *Normandie Univ, UNIHAVRE, Laboratoire Ondes et Milieux Complexes, UMR CNRS 6294, France* • Rebecca Sainidou, *Normandie Univ, UNIHAVRE, Laboratoire Ondes et Milieux Complexes, UMR CNRS 6294, France* • Pascal Rembert, *Normandie Univ, UNIHAVRE, Laboratoire Ondes et Milieux Complexes, UMR CNRS 6294, France* • Bruno Morvan, *Normandie Univ, UNIHAVRE, Laboratoire Ondes et Milieux Complexes, UMR CNRS 6294, France* • Nikolaos Stefanou, *Department of Solid State Physics, National and Kapodistrian University of Athens, Greece* The acoustic response of double-porosity liquid-saturated granular materials consisting of close-packed porous spheres, is studied through the full elastodynamic layer-multiple-scattering method. Unprecedented modes, arising from slow longitudinal waves peculiar to poroelastic media, induce remarkable features in the acoustic behavior of these materials, such as broad or narrow dispersionless absorption bands.
18:00 - 19:00	**NATURE RESEARCH SYMPOSIUM: ROUND TABLE DISCUSSION** • Harry A. Atwater, *California Institute of Technology, USA* • Giuseppe Strangi, *Case Western Reserve University, USA* • Lucie Green, *UCL-MSSL, United Kingdom* • Andrei Faraon, *California Institute of Technology, USA* Round Table Discussion moderated by Lina Persechini, Maria Maragkou and Rachel Won.	

17:30 - 17:45	**Potential Applications for Metamaterials in Measuring Astrophysical Magnetic Fields** Invited oral : • Lucie Green, *UCL-MSSL, United Kingdom* • David Long, *UCL-MSSL, United Kingdom* Understanding how magnetic fields develop and evolve is key to understanding the Sun. The instruments used are currently excessively heavy and therefore expensive. Metamaterials could provide an opportunity to build the next generation of lightweight miniaturized instrumentation.	**Experimental 3D Illusion for Magnetic Fields** • Rosa Mach-Batlle, *Universitat Autonoma de Barcelona, Spain* • Albert Parra, *Universitat Autonoma de Barcelona, Spain* • Sergi Laut, *Universitat Autonoma d e Barcelona, Spain* • Carles Navau, *Universitat Autonoma de Barcelona, Spain* • Nuria Del-Valle, *Universitat Autonoma de Barcelona, Spain* • Alvaro Sanchez, *Universitat Autonoma de Barcelona, Spain* An experimental realization of the magnetic illusion of transforming the magnetic signature of a ferromagnetic sphere into that of a perfect diamagnetic one is presented. This requires considering negative values of the magnetostatic permeability, which are effectively obtained by a tailored set of currents.
17:45 - 18:00		**Study of graded index metamaterials: transparency and control of electromagnetic waves** • Benjamin Vial, *Queen Mary, University of London, United Kingdom* • Yang Hao, *Queen Mary, University of London, United Kingdom* We recently developed a general purpose method to control the amplitude and phase of a wave propagating in a two dimensional (2D) inhomogeneous isotropic medium [1]. In this contribution we provide results on the Transverse Magnetic (TM) case, for a one dimensional (1D) problem and approximate the required permittivity profile with a graded index metamaterial.
18:00 - 19:00	**NATURE RESEARCH SYMPOSIUM: ROUND TABLE DISCUSSION** • Harry A. Atwater, *California Institute of Technology, USA* • Giuseppe Strangi, *Case Western Reserve University, USA* • Lucie Green, *UCL-MSSL, United Kingdom* • Andrei Faraon, *California Institute of Technology, USA* Round Table Discussion moderated by Lina Persechini, Maria Maragkou and Rachel Won.	

Metamaterials 2017
Program

Wednesday, 30th August

09:00 - 10:00	PLENARY SESSION III	
09:00	PLENARY SESSION III Session chairperson : Sergei Tretyakov	
09:00 - 10:00	Plasmonic Metamaterials 2.0: from Nanophotonics to Energy Applications • Vladimir M. Shalaev, *School of Electrical & Computer Engineering and Birck Nanotechnology Center, Purdue University, USA* The fields of nanophotonics, plasmonics and optical metamaterials have enabled unprecedented ways to control the flow light at both the micro- and nanometer length scales, unfolding new optical phenomena, with a potential to reshape the existing optical technologies and create new ones. In this presentation, emerging plasmonic, metamaterial and metasurfaces concepts as well as material platforms will be discussed with the focus on practical photonic technologies for communication, quantum optics, bio-medical and energy applications.	
10:00 - 10:30	COFFEE BREAK (WEDNESDAY MORNING)	
10:30 - 12:30	ORAL SESSIONS (WEDNESDAY MORNING)	
10:30	SPECIAL SESSION ON MECHANICAL METAMATERIALS Organizer: Muamer kadic Session chairperson: Muamer Kadic	QUANTUM PLASMONICS AND SUPERCONDUCTING METAMATERIALS Session chairperson: Stefan Rotter
10:30 - 10:45	Parity-Time Synthetic Phononic Media **Invited oral :** • Johan Christensen, *UC3M, Spain* Classical systems containing cleverly devised combinations of loss and gain elements constitute extremely rich building units that can mimic non-Hermitian properties, which conventionally are attainable in quantum mechanics only. Parity-time (PT) symmetric media, also referred to as synthetic media, have been devised in many optical systems with the ground breaking potential to create nonreciprocal structures and one-way cloaks of	Suppression of Fluorescence Quenching and Strong-Coupling in Plasmonic Nanocavities • Nuttawut Kongsuwan, *Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom* • Angela Demetriadou, *Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom* • Rohit Chikkaraddy, *Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom*

Metamaterials 2017
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10:00 - 10:30	COFFEE BREAK (WEDNESDAY MORNING)	
10:30 - 12:30	ORAL SESSIONS (WEDNESDAY MORNING)	
10:30	METASURFACES II Session chairpersons: Christophe Caloz, Filippo Capolino	TUNABLE, RECONFIGURABLE AND NONLINEAR METAMATERIALS Session chairperson: Pavel Belov
10:30 - 10:45	Optical Metasurfaces to Bring Computer Graphics Tricks to Real Optical Systems • Alexander Minovich, *King's College London, United Kingdom* • Manuel Peter, *Rheinische Friedrich-Wilhelms-University Bonn, Germany* • Felix Bleckmann, *Rheinische Friedrich-Wilhelms-University Bonn, Germany* • Manuel Becker, *Rheinische Friedrich-Wilhelms-University Bonn, Germany* • Stefan Linden, *Rheinische Friedrich-Wilhelms-University Bonn, Germany*	Integration of metamaterials with optical fiber technologies **Invited oral :** • Nikolay Zheludev, *University of Southampton, UK and NTU, Singapore, United Kingdom & Singapore* • Eric Plum, *University of Southampton, United Kingdom* • Kevin Macdonald, *University of Southampton, United Kingdom* We will review recent advances in metamaterials research that aims to develop switchable and

invisibility. Here we demonstrate a feasible approach for the case of elasticity where the most important ingredients within synthetic materials, loss and gain, are achieved through electrically biased piezoelectric semiconductors.

- **Felix Benz,** *Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom*
- **Vladimir A. Turek,** *Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom*
- **Ulrich F. Keyser,** *Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom*
- **Jeremy J. Baumberg,** *Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom*
- **Ortwin Hess,** *Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom*

Fluorescence emission of a quantum emitter is dominated by its optical environment, and it was proven that an emitter is quenched when it is placed too closed to metal nanoparticles. Here, we present the spatio-temporal dynamics of the emitter and demonstrate that quenching can in fact be suppressed in plasmonic nanocavities. By varying the lateral position of an emitter through DNA-origami technique, our results are confirmed with experimental measurements.

10:45 - 11:00

Nonlocal Plasmonic Effects on Dipole Decay Dynamics in the Weak and Strong Coupling Regimes

- **Radoslaw Jurga,** *Istituto Italiano di Tecnologia, Italy*
- **Stefania D'Agostino,** *Istituto Italiano di Tecnologia, Italy*
- **Fabio Della Sala,** *Istituto Italiano di Tecnologia, Italy*
- **Cristian Ciracì,** *Istituto Italiano di Tecnologia, Italy*

We simulate numerically a quantum emitter near metal nanostructures described with nonlocal models. The spontaneous emission rate and fluorescence enhancement become lower than anticipated with local models. In the strong coupling regime, the dipole moment required for the onset of Rabi splitting is increased.

11:00 - 11:15

Poroelastic Metamaterials With Negative Absolute Effective Static Compressibility

- **Jingyuan Qu,** *Institute of Applied Physics, Institute for Nanotechnology, Karlsruhe Institute for Technology, Germany*
- **Muamer Kadic,** *Institut FEMTO-ST, CNRS, Université Bourgogne Franche-Comté, France*
- **Martin Wegener,** *Institute of Applied Physics, Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany*

We present a three-dimensional poroelastic metamaterial exhibiting an isotropic effective expansion in response to an increased hydrostatic

Transformation Optics Insight into Plasmon-Exciton Coupling in Optical Cavities

Invited oral :

- **Antonio I. Fernández-Domínguez,** *Universidad Autónoma de Madrid and Condensed Matter Physics Center (IFIMAC), Spain*

We present a transformation-optics-inspired theoretical description of the electromagnetic coupling between a two-level system and the localized modes supported by the most paradigmatic plasmonic cavity: a pair of metallic spheres separated by a nanometric gap. Our method exploits the invariance of Maxwell´s Equations under geometric

- **Anatoly Zayats,** *King's College London, United Kingdom*

We present optical diffuse metasurfaces which implement a method of normal mapping widely used in computer graphics for the design of 3D features. The normal mapping approach based on metasurfaces can complement traditional optical engineering methods (surface profiling and GRIN) in the design of novel optical elements..

tuneable functional nanostructures. Metamaterials research has migrated from the study of metallic plasmonic structures and now also embraces a large variety of advanced material platforms, including dielectrics, semiconductors, superconductors, topological insulators and complex hybrid systems. We will talk about coherent control of metasurfaces, all-optical and electro-optical switching with reconfigurable nano-opto-mechanical and phase change metamaterials and the way functional metamaterials can be integrated into fiber platform

10:45 - 11:00

Scattering from a Nonlinear Metasurface

- **Karim Achouri,** *Ecole Polytechnique de Montréal, Canada*
- **Christophe Caloz,** *Ecole Polytechnique de Montréal, Canada*

We present a closed-form analysis of electromagnetic scattering from a nonlinear metasurface. For simplicity, we restrict our attention to the case of an isotropic second-order nonlinear metasurface. We derive the reflectionless conditions for such a nonlinear metasurface, and show that those conditions depend on the direction of wave propagation, which reveals the nonreciprocal nature of the structure. Next, we provide approximate transmitted field expressions obtained by perturbation theory, and we shall present FDTD validations at the conference.

11:00 - 11:15

Multi-Channel Reflectors: Versatile Performance Experimentally Tested

- **Svetlana Tcvetkova,** *Aalto University, Finland*
- **Viktar Asadchy,** *Aalto University, Finland*
- **Ana Díaz-Rubio,** *Aalto University, Finland*
- **Do-Hoon Kwon,** *Aalto University, Finland*
- **Sergei Tretyakov,** *Aalto University, Finland*

We investigate multi-channel reflectors, such as a three-channel power splitter and a five-channel isolating mirror. These metasurface reflectors are able to control reflections from and into several directions while possessing a flat surface. We design,

Third Harmonic Generation at Anapole Modes in Nanostructured All-dielectric Germanium Antennas

- **Yi Li,** *Imperial College London, United Kingdom*
- **Gustavo Grinblat,** *Imperial College London, United Kingdom*
- **Michael P. Nielson,** *Imperial College London, United Kingdom*
- **Rupert F. Oulton,** *Imperial College London, United Kingdom*
- **Stefan A. Maier,** *Imperial College London, United Kingdom*

	pressure of a surrounding gas or liquid. This behavior corresponds to a negative effective static compressibility. The metamaterial is composed of a single constituent solid.	transformations to obtain analytical expressions for the spectral density evaluated in the surroundings of this nanostructure. We use this tool to perform a thorough analysis of the Wigner-Weisskopf problem for this system and investigate the material and geometric conditions giving rise to single exciton-plasmon strong coupling phenomena.
11:15 - 11:30	**Slow waves, elastic rainbow and dynamic anisotropy with a cluster of resonant rods on an elastic halfspace** • Andrea Colombi, *Imperial College London, United Kingdom* • Richard Craster, *Imperial College London, United Kingdom* • Matt Clark, *University of Nottingham, United Kingdom* • Daniel Colquitt, *University of Liverpool, United Kingdom* Metamaterial designs combining graded arrays of resonators and elastic wave excitation are opening new possibilities to broadband control the propagation of mechanical waves in solid media. In this presentation we report on the recent development of a graded metasurface that supports a variety of phenomena including wave focusing, re-routing, rainbow trapping and mode conversion.	
11:30 - 11:45	**Rational design of reconfigurable prismatic architected materials** • Johannes Overvelde, *AMOLF, Netherlands* • James Weaver, *Harvard, United States* • Chuck Hoberman, *Harvard, United States* • Katia Bertoldi, *Harvard, United States* Inspired by the structural diversity and foldability of the prismatic geometries that can be constructed using the snapology origami-technique, here we introduce a robust design strategy based on space-filling polyhedra to create 3D reconfigurable materials comprising a periodic assembly of rigid plates and elastic hinges. Media link(s) : A video preview can be watched through **this link**, see also recently published article in **Nature.**	**Towards Ultrastrong Plexcitonic Coupling by Dynamical Molecular Aggregation** • Francesco Todisco, *CNR Nanotec, Italy* • Milena De Giorgi, *CNR Nanotec, Italy* • Marco Esposito, *CNR Nanotec, Italy* • Luisa De Marco, *CNR Nanotec, Italy* • Alessandra Zizzari, *CNR Nanotec, Italy* • Monica Bianco, *CNR Nanotec, Italy* • Lorenzo Dominici, *CNR Nanotec, Italy* • Dario Ballarini, *CNR Nanotec, Italy* • Valentina Arima, *CNR Nanotec, Italy* • Giuseppe Gigli, *CNR Nanotec, Italy* • Daniele Sanvitto, *CNR Nanotec, Italy* We studied the dynamic evolution of the strong plasmon-exciton coupling between an heptamethine dye and silver nanostructures in a microfluidic device. We clearly observed a continuous increase of the Rabi splitting due to the gradually deposition of injected molecules on the metallic nanostructures surface. For sufficiently long interaction times, we demonstrated that the number of deposited molecules becomes high enough to reach the ultrastrong coupling regime.

Wednesday

	fabricate, and experimentally study these new devices, confirming that the performance is nearly perfect. Media link : **See arxiv preprint**	We present germanium nanosystems with a highly improved electric field confinement effect at anapole and higher-order modes, leading to third harmonic generation conversion efficiencies as large as 0.001% at an emission wavelength of 550 nm. The anapole near-field intensity distributions are unveiled by mapping the emission across the nanodisks, which show excellent agreement with numerical simulations.
11:15 - 11:30	**Dielectric Rod Metasurfaces: Exploiting Toroidal and Magnetic Dipole Resonances** • Odysseas Tsilipakos, *Foundation for Research and Technology Hellas, Greece* • Anna Tasolamprou, *Foundation for Research and Technology Hellas, Greece* • Thomas Koschny, *Ames Laboratory and Iowa State University, USA* • Maria Kafesaki, *Foundation for Research and Technology Hellas & University of Crete, Greece* • Eleftherios Economou, *Foundation for Research and Technology Hellas & University of Crete, Greece* • Costas Soukoulis, *Foundation for Research and Technology Hellas & Ames Laboratory and Iowa State University, Greece & USA* We demonstrate matched toroidal and magnetic dipole resonances in dielectric rod metasurfaces by combining an elliptical rod cross-section or a coupled-rod molecule with inter-cell coupling. Importantly, the resonances remain matched when varying the permittivity or rod radius, opening the possibility for wavefront shaping and tunable perfect absorption.	**Strong spatial nonlinear effects in anisotropic nonlinear metamaterial plasmonic waveguides: stationary and temporal results** • Mahmoud M. R. Elsawy, *Aix-Marseille University & CNRS, France* • Gilles Renversez, *Aix-Marseille University & CNRS, France* Using several methods, we study the nonlinear solutions of plasmonic slot waveguides with an anisotropic metamaterial core, exhibiting a positive Kerr-type nonlinearity, surrounded by two metal claddings. We demonstrate that for a highly anisotropic diagonal elliptical core permittivity the bifurcation threshold of the asymmetric mode in symmetric structures is reduced from the GW/m level, obtained for the isotropic case, to 50 MW/m level.
11:30 - 11:45	**Non-Local Metasurfaces for Perfect Control of Reflection and Transmission** Invited oral : • Sergei Tretyakov, *Aalto University, Finland* • Ana Díaz-Rubio, *Aalto University, Finland* • Viktar Asadchy, *Aalto University, Finland* • Do-Hoon Kwon, *Aalto University and University of Massachusetts Amherst, Finland and USA* Reflected and transmitted waves can be shaped by controlling the phase of reflection and transmission coefficients of antenna arrays or thin composite layers. This is the operational principle of phased array antennas and reflectarrays, which can be used also to design reflecting and transmitting metasurfaces. Recently, it has been recognized that such phase-gradient reflectors always produce some parasitic scattering into unwanted directions. In this review talk we present and discuss our recent results on non-local (spatially dispersive) gradient metasurfaces which do not have this drawback and demonstrate perfect anomalous reflection and transmission of plane waves into any desired direction. Media link : **meta.aalto.fi**	**Sphere Dimers Of High Refractive Index Dielectric Particles As Elementary Units For Building Optical Switching Devices** • Angela I Barreda, *Department of Applied Physics, Faculty of Science, University of Cantabria, Spain* • Hassan Saleh, *Centre Commun de Ressources en Microondes CCRM, France* • Amélie Litman, *Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France* • Francisco González, *Department of Applied Physics, Faculty of Science, University of Cantabria, Spain* • Fernando Moreno, *Department of Applied Physics, Faculty of Science, University of Cantabria, Spain* • Jean-Michel Geffrin, *Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France* We present unambiguous experimental evidence in the microwave range that a dimer of spherical High Refractive Index dielectric particles behaves as an elementary block for building switching devices whose binary state only depends on the polarization of the incident radiation

11:45 - 12:00	**Unidirectional Wave Propagation in Chiral Elastic Lattices** • **Giorgio Carta,** *Liverpool John Moores University, United Kingdom* • **Ian Jones,** *Liverpool John Moores University, United Kingdom* • **Natasha Movchan,** *University of Liverpool, United Kingdom* • **Alexander Movchan,** *University of Liverpool, United Kingdom* • **Michael Nieves,** *Liverpool John Moores University, United Kingdom* We present a novel design of a chiral elastic metamaterial, consisting of an elastic lattice with gyroscopic spinners. In such a medium, waves can be channelled along a single direction. The unidirectional wave pattern is very localised and it can be deviated by changing the arrangement of the gyros.	**Quantum Dynamics of an Interacting Electron Gas in a Metal Nanosphere** • **Alexandra Crai,** *Imperial College London, United Kingdom* • **Andreas Pusch,** *Imperial College London, United Kingdom* • **Doris E. Reiter,** *University of Münster, Germany* • **Benjamin A. Burnett,** *NG Next, Northrop Grumman Corporation, USA* • **Tilmann Kuhn,** *University of Münster, Germany* • **Ortwin Hess,** *Imperial College London, United Kingdom* Plasmonic nanostructures provide pathways for light to generate hot electrons or manipulate chemical reactions on the nanoscale. However, when the size of the nanoparticle becomes smaller and smaller it is questionable whether a classical theory describes the microscopic behaviour of the electronic system adequately. Here, we study the optically generated many-particle dynamics using the density matrix formalism providing a quantum picture of the optical response of a metal nanosphere. The resulting dielectric susceptibility spectra show discrete resonances resulting from a collective response mediated by the Coulomb interaction between the electrons.
12:00 - 12:15	**Static Non-reciprocity in Mechanical Metamaterials** • **Corentin Coulais,** *Institute of Physics, University of Amsterdam, Netherlands* We introduce mechanical metamaterials with suitably designed nonlinearity and asymmetry that exhibit non-reciprocity, namely they transmit motion differently depending on the direction of the input forcing.	**Quantum optics of zero-index media** • **Iñigo Liberal,** *Public University of Navarre, Spain* • **Nader Engheta,** *University of Pennsylvania, United Stated* During recent years zero-index media have offered unique tools for the control and manipulation of electromagnetic waves. However, similar concepts and techniques could be transplanted and utilized in the manipulation of quantized fields. As a specific example, we demonstrate theoretically that supercoupling phenomena in a N-port epsilon-and-mu-near-zero (EMNZ) hub can be utilized in the generation of subradiant, maximally entangled, multi-qubit states.

11:45 - 12:00		**Structure Reconfigurable Metamaterial Plate with MEMS Technique for THz Wave Beam Shaping** • **Zhengli Han,** *Riken, Japan* • **Hiroshi Toshiyoshi,** *The University of Tokyo, Japan* This paper reports a structure reconfigurable metamaterial plate for terahertz (THz) wave beam shaping. The metamaterial plate contains an array of micro split ring resonator that controls the local properties of THz wave transmission or reflection. We add MEMS (micro electro mechanical system) component (movable cantilever) to each resonator to tune its resonance. Therefore by the reconfiguration on the resonator array, it enables beam shaping of THz wave when it propagates through the metamaterial plate.
12:00 - 12:15	**Metasurfaces for Field Manipulation and Sensing** Invited oral : • **Vincenzo Galdi,** *University of Sannio, Department of Engineering, Italy* This paper summarizes some recent results on the design, fabrication and characterization of metasurfaces for field manipulation and sensing. First, we present the integration of a phase-gradient plasmonic metasurface on the tip of an optical fiber. As possible application examples, we illustrate the beam steering and the excitation of surface waves. This latter can find interesting applications in label-free optical sensing. Subsequently, we present the design of coding metasurfaces for diffuse scattering. More specifically, via a theoretical study of the relevant scaling-laws, we derive some absolute and realistic bounds on the scattering-cross-section reduction, and we introduce a simple, deterministic sub-optimal design strategy.	**Tunability Of Ferroelectric Superlenses In The Mid-Infrared Regime** • **Lukas Wehmeier,** *Technische Universität Dresden, Germany* • **Jonathan Doering,** *Technische Universität Dresden, Germany* • **Stephan Winnerl,** *Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Germany* • **Susanne C. Kehr,** *Technische Universität Dresden; cfaed – Center For Advancing Electronics Dresden, Germany* • **Lukas M. Eng,** *Technische Universität Dresden; cfaed – Center For Advancing Electronics Dresden, Germany* Ferroelectric perovskites are preferential candidates for designing superlens efficiencies at infrared (IR) wavelengths. The evanescent image formed by such superlenses is thoroughly inspected by applying scanning near-field optical microscopy and spectroscopy. The work here focuses on the impact of the dielectric polarization in such ferroelectrics, that provides superlens tunability via the electric field control of the local-scale optical anisotropy in these materials.

12:15 - 12:30	**Band Gap Formation and Tunability in Stretchable Serpentine Interconnects** • **Pu Zhang,** *University of Manchester, United Kingdom* • **William Parnell,** *University of Manchester, United Kingdom* In this work, we show that the undulating geometry of the serpentine interconnects will generate phononic band gaps in a wide frequency range. In addition, the band structures of the serpentine interconnects can be tuned by applying pre-stretch deformation.	**Optical Response Of Niobium Around The Superconducting Transition Temperature** • **Chun Yen Liao,** *Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, United Kingdom* • **Harish N. S. Krishnamoorthy,** *Centre for Disruptive Photonic Technologies, SPMS, TPI, Nanyang Technological University, Singapore* • **Vassili Savinov,** *Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, United Kingdom* • **Jun-Yu Ou,** *Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, United Kingdom* • **Chunli Huang,** *Centre for Disruptive Photonic Technologies, SPMS, TPI, Nanyang Technological University, Singapore* • **Giorgio Adamo,** *Centre for Disruptive Photonic Technologies, SPMS, TPI, Nanyang Technological University, Singapore* • **Eric Plum,** *Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, United Kingdom* • **Kevin F. MacDonald,** *Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, United Kingdom* • **Yidong D. Chong,** *Centre for Disruptive Photonic Technologies, SPMS, TPI, Nanyang Technological University, Singapore* • **O.L. Muskens,** *School of Physics and Astronomy, University of Southampton, United Kingdom* • **Cesare Soci,** *Centre for Disruptive Photonic Technologies, SPMS, TPI, Nanyang Technological University, Singapore* • **Feodor V. Kusmartsev,** *Department of Physics, Loughborough University, Loughborough, United Kingdom* • **Din Ping Tsai,** *Department of Physics, National Taiwan University, Taipei , Taiwan* • **Nikolay I. Zheludev,** *Centre for Disruptive Photonic Technologies, SPMS, TPI, Nanyang Technological University, Singapore* Our measurement of the optical response of unpatterned and nanostructured niobium films show a strong variation around the supeconducting transition temperature of 9K and provides the first evidence of link between superconductivity and optical range plasmonics.
12:30 - 14:00	**LUNCH BREAK (WEDNESDAY)**	
14:00 - 15:30	**ORAL SESSIONS (WEDNESDAY - AFTERNOON 1)**	

12:15 - 12:30		**Luminescence Control in Color Tunable Perovskites Metasurfaces** • **Giorgio Adamo,** *Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore, Singapore* • **Behrad Gholipour,** *Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, UK, United Kingdom* • **Kar Cheng Lew,** *Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore, Singapore* • **Daniele Cortecchia,** *Interdisciplinary Graduate School, Nanyang Technological University, Singapore and Energy Research Institute @ NTU (ERI@N), Nanyang Technological University, Singapore , Singapore* • **Harish N. S. Krishnamoorthy,** *Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore, Singapore* • **Annalisa Bruno,** *Energy Research Institute @ NTU (ERI@N), Nanyang Technological University, Singapore, Singapore* • **Jin-Kyu So,** *Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore, Singapore* • **Mohammad D. Birowosuto,** *CINTRA UMI CNRS/NTU/THALES 3288, Singapore, Singapore* • **Nikolay I. Zheludev,** *Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore and Optoelectronics Research Centre & Centre for Photonic Metamaterials, University of Southampton, UK, Singapore* • **Cesare Soci,** *Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore, Singapore* We demonstrate that nanopatterning of solution-processable metal-halide perovskite films can be used to control their luminescence spectra and lead to up to five-fold increase of luminescence yield.
12:30 - 14:00	**LUNCH BREAK (WEDNESDAY)**	
14:00 - 15:30	**ORAL SESSIONS (WEDNESDAY - AFTERNOON 1)**	

14:00	EXOTIC EFFECTS AT MICROWAVES Session chairperson: Alessio Monti	OPTICAL METAMATERIALS Session chairperson: Richard Ziolkowski
14:00 - 14:15	**The Accurate Prediction of Longitudinal Electromagnetic Mode Profile Sculpting in Wire Media using Concepts of Spatial Dispersion.** • Jonathan Gratus, *Physics Department Lancaster University and the Cockcroft Institute, United Kingdom* • Taylor Boyd, *Physics Department Lancaster University and the Cockcroft Institute, United Kingdom* • Paul Kinsler, *Physics Department Lancaster University and the Cockcroft Institute, United Kingdom* • Rosa Leitizia, *Engineering Department Lancaster University and the Cockcroft Institute, United Kingdom* Using a wire medium with dielectric wires of varying radius, we can sculpt longitudinal electromagnetic wave profiles. Applications include signal processing and accelerators. The required modulation of the wires was calculated using concepts of spatial dispersion, and full 3D CST simulations were run. Predictions and simulations were in excellent agreement.	**Optical Metamaterials Resonances with Large Quality Factor** Invited oral : • Costas Soukoulis, *Iowa State University, USA* Most metamaterials (MMs) to date are made with metallic constituents, resulting in significant dissipation loss in the optical domain. Therefore, we need to find other ways to create high-quality resonators with less dissipative loss for the meta-atoms. One innovative approach we plan is to reduce dissipative losses by making use of dielectrics rather than metals for building the EM resonators. This avoids resonant loss in the metals and we indeed demonstrate electric and magnetic dielectric metamaterial resonators with very large quality factors. The resulting structures can be straightforwardly scaled at optical frequencies to create low-loss MMs with a wide range of properties.
14:15 - 14:30	**Strong Variations of Microwave Field Inside Opal-Based Artificial Crystals** • Anatoly Rinkevich, *Institute of Metal Physics, Russia* • Dmitry Perov, *Institute of Metal Physics, Russia* Metamaterials based on opal matrix and containing magnetic particles are studied both experimentally and theoretically and their complex refractive coefficients at frequencies of millimeter waveband are obtained. A parameter, characterizing the nonuniformity of electromagnetic fields at different distances from a magnetic particle, has been introduced and calculated. It is found that the nonuniformity drastically varies depending on the distance from magnetic particle and on external magnetic field.	
14:30 - 14:45	**Nonlocality of Wire Media – Local Thickness-Dependent Permittivity Model** Invited oral : • Alexander B. Yakovlev, *Department of Electrical Engineering, University of Mississippi, USA* A closed-form expression for the local thickness-dependent permittivity is derived for a general case of nonlocal wire medium with lumped impedance insertions and terminated with different impedance surfaces. The obtained analytical form of local permittivity accurately takes into account the effects	**Resonant Dielectric Particles with Refractive Index Less Than Two** Invited oral : • Boris Lukiyanchuk, *Data Storage Institute, Agency for Science, Technology and Research Singapore, Singapore* Materials with relatively small refractive indices ( ), such as glass, quartz, polymers, some ceramics, etc., are the basic materials in most of the optical components (lenses, optical fibres, etc.). In this review, we present some of the phenomena and

14:00	TRANSFORMATION ELECTROMAGNETICS Session chairperson: Ross McPhedran	OPTICAL FORCES Session chairperson: Constantin Simovski
14:00 - 14:15	**Conformal Talbot Effect** • Hui Liu, *Nanjing University, China* Tconformal Talbot effect in such a system has a potential application to transfer digital information without diffraction. Our findings demonstrate the photon controlling ability of conformal optical devices in a feasible experiment system.	**Optical Forces: Some Fundamentals and Some Surprises** Invited oral : • Stephen Barnett, *University of Glasgow, United Kingdom* We address the general problem of evaluating optical forces on general dielectric and magneto-dielectric materials. Our starting point is the familiar Lorentz force law and we exploit symmetries and physical reasoning to build up a complete theory. At the quantum level, this allows us to identify the mechanical properties of photons propagating through such media.
14:15 - 14:30	**Curvature and Transformations** • Paul Kinsler, *Lancaster University, United Kingdom* • Jonathan Gratus, *Lancaster University, United Kingdom* • Martin McCall, *Imperial College London, United Kingdom* We discuss the presence and role of curvature in transformation optics and other transformation fields. Further, we show where and why it is not induced by cloaking transformations, but where and why it can be in other cases.	
14:30 - 14:45	**Quasistatic Matamaterials: Magnetic Coupling Enhancement by Effective Space Cancellation** • Jordi Prat-Camps, *Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences / Institute for Theoretical Physics, University of Innsbruck, Austria* • Carles Navau, *Departament de Fisica, Universitat Autònoma de Barcelona, Spain* • Alvaro Sanchez, *Departament de Física, Universitat Autònoma de Barcelona, Spain* Metamaterials and transformation optics have	**Plasmonic Trapping and Antitrapping of Nanoparticles** • Alexander Shalin, *ITMO University, Russia* • Aliaksandra Ivinskaya, *ITMO University, Russia* • Mihail Petrov, *ITMO University, Russia* • Andrey Bogdanov, *ITMO University, Russia* • Pavel Ginzburg, *Tel Aviv University, Israel* Optical tweezers performance is investigated when the Gaussian beam is focused on the metal substrate with nanoparticle. When the beam is focused above the substrate optical force increases about an order

of spatial dispersion and loads/terminations in the averaged sense per length of wire medium. It enables to solve in the local model framework various far-field and near-field electromagnetic problems involving a nonlocal bounded wire medium with lumped loads and impedance surface terminations.

possible applications arising from the interaction of light with particles made of such materials with a refractive index less than two. The vast majority of the physics involved can be described with the help of the exact analytical solution of Maxwell's equations for spherical particles (so called Mie theory). We also discuss some other particle geometries (spheroidal, cubic, etc.) and different particle configurations (isolated or interacting) and draw an overview of possible applications of such materials, in connection with field enhancement and super resolution nanoscopy.

14:45 - 15:00

15:00 - 15:15

Exceptional Points, Principal Modes and Particle-like Scattering States in Multi-mode Waveguides

Invited oral :

• **Stefan Rotter,** *Vienna University of Technology (TU Wien), Austria*

I will present new theoretical insights as well as experimental data on coherent transmission through multi-mode waveguides. Specifically, I will demonstrate how to implement an asymmetric mode-switching protocol through encircling a so-called exceptional point as well as dispersion-free transmission through the so-called "principal waveguide modes".

Broadband Suppression of Backscattering at Optical Frequencies

• **Mohamed Ismail Abdelrahman,** *Karlsruhe Institute of Technology, Germany*
• **Ivan Fernandez-Corbaton,** *Karlsruhe Institute of Technology, Germany*
• **Carsten Rockstuhl,** *Karlsruhe Institute of Technology, Germany*

We present a novel approach to realize a broadband suppression of backscattering at optical frequencies where materials are intrinsically nonmagnetic. Our approach relies on using spheres made of low permittivity materials. Such spheres exhibit comparable electric and magnetic responses to the illumination for a large number of multipole moments over a broad spectrum of wavelengths, which in turn is the key to a vanishing backscattering. so-called exceptional point as well as dispersion-free transmission through the so-called "principal waveguide modes".

greatly expanded the possibilities for controlling electromagnetic waves and static fields. Here, we present a novel and broadly applicable way to increase magnetic coupling between two distant elements, by using the properties of extreme anisotropic magnetic metamaterials. Based on transformation optics, we analytically demonstrate how the magnetic coupling between emitting and receiving coils in a general system can be enhanced by surrounding them with magnetic metamaterials, exactly as if the distance between them has been reduced. The validity of the theoretical results is confirmed by experimentally demonstrating that using magnetic metamaterials results in a boost on the efficiency in the wireless transmission of power between circuits, since this efficiency directly depends on the magnetic coupling between emitter and receiver.

of magnitude due to evanescent field of surface plasmon. Novel effect of repulsion from Gaussian beam ("anti-trapping") is obtained when the beam waist is moved below the substrate which is confirmed by both the analytical approach and finite element simulation.
Media link : See arxiv preprint:
https://arxiv.org/abs/1611.01007

14:45 - 15:00

Metamaterial-Based Bessel Beam Launcher

• **Nikolaos Chiotellis,** *University of Michigan, USA*
• **Anthony Grbic,** *University of Michigan, USA*

A coaxially fed device that generates Bessel beams over a broad bandwidth is presented. The concept of quasi-conformal transformation optics is employed to engineer an inhomogeneous, isotropic dielectric region that bends the waves emitted by an electrically small monopole into a paraxial Bessel beam. The axicon angle remains relatively constant over a large frequency range. As a result, non-diffracting, highly localized pulses (X waves) can be emitted under a pulse excitation. The design methodology and the metamaterial implementation of the launcher are discussed. The device is currently being fabricated.

All-Purpose Beam Optimization

• **Ivan Fernandez-Corbaton,** *Kalrsruhe Institute of Technology, Germany*
• **Carsten Rockstuhl,** *Karlsruhe Institute of Technology, Germany*

We present a general way to optimize electromagnetic beams for light-matter interactions. Given an object and a desired function like exterting torque or force, minimizing absorption, etc ..., we determine the most efficient beam for the task. We also obtain the figure of merit of the optimal beam (e.g. in force per Watt), which sets an absolute uppper bound.

15:00 - 15:15

Does Transformation Optics Work At Interfaces?

• **Lieve Lambrechts,** *Vrije Universiteit Brussel, Belgium*
• **Vincent Ginis,** *Vrije Universiteit Brussel, Belgium*
• **Jan Danckaert,** *Vrije Universiteit Brussel, Belgium*
• **Philippe Tassin,** *Chalmers University, Sweden*

In this contribution, we use the geometrical formalism of transformation optics to investigate reflection at the interface between two media. First, we highlight the difficulty of transformation optics when considering discontinuous coordinate transformations and, subsequently, we present reflective properties of discontinuously transformed media as a function of the coordinate stretching.

Radiative Pulling Forces Nearby a Slab of Hyperbolic Metamaterial

• **Igor Nefedov,** *Aalto University, Finland*
• **Alexander Shalin,** *``Nanooptomechanics" Laboratory, ITMO University, St. Petersburg, Russia*

In this paper we demonstrate that a finite-thickness slab of a hyperbolic metamaterial (HMM),surrounded by isotropic medium,can support either forward or backward waves if the negative component of the permittivity tensor corresponds to the coordinate axis, orthogonal to slab interfaces. If the waveguide dispersion is the negative, the lateral radiative force outside of HMM is always the pullinfg force, i.e. is directed toward a source of electromagnetic energy flow.

15:15 - 15:30		**Ultra-Compact Plasmonic Wave Splitter in NIR Domain** • **Yulong Fan,** *C2N - University of Paris Sud, France* • **Helena Bochkova,** *C2N - University of Paris Sud, France* • **Anatole Lupu,** *C2N - University of Paris Sud, France* • **Andre de,** *C2N - University of Paris Sud, France* in this study we describe the design, the simulation and the characterization of a NIR domain plasmonic wavelength demultiplexer integrated on SOI waveguide. The reported device is made of a few chains of gold nano cut wires with a total feature dimensions of 4Qm4Qm and is acting as a 1.3/1.5 Qm wavelength demultiplexer for optical communication. The modeling and experimental results show that the considered approach opens the avenue toward a new generation of ultra-compact optical devices.
15:30 - 17:30	**COFFEE BREAK AND POSTER SESSION (WEDNESDAY AFTERNOON)**	
15:30	**POSTER SESSION** Session chairperson: Mirko Barbuto	

1 - High Gain Metasurface Antenna with Multiple Feeding Structure

- **Niamat Hussain,** *Ajou University, Korea (South)*
- **Ikmo Park,** *Ajou University, Korea (South)*

This paper presents the design of a planar, low-profile, high-gain, wide-gain-bandwidth metasurface antenna with a multiple feeding structure. The antenna structure consists of a 5 5 array of square patch metasurface and a planar feeding structure, both of which are patterned on a high-permittivity, electrically thin, GaAs substrate. The metasurface is etched on the top side of the substrate, while the feeding structure, which is a wideband, leaky-wave, center-fed open-ended slotline, is printed on the bottom side of the substrate. The antenna showed maximum broadside gain of 15.5 dBi, radiation efficiency of 73%, and a 3-dB-gain bandwidth of more than 17.3% (0.342–0.408 THz).

2 - Dispersionless Slow Wave In Waveguides Composed Of Two Types Of Single-Negative Matematerials

- **Zhiwei Guo,** *University of TongJi, China*
- **Haitao Jiang,** *University of TongJi, China*
- **Hong Chen,** *University of TongJi, China*

We study the dispersionless slow wave in waveguides composed of two kinds of single-negative metamaterials. The underlying physical mechanism is the compensation effect of power flow in two sides of the waveguide. This dispersionless slow wave may be used in signal processing and optical storage applications.

3 - The Resonant Waveguide Elements in the Spatially Confined 2-D Photonic Crystals: The Rigorous Models of the Exact Absorbing Conditions Method

- **Nataliya Yashina,** *Institute of Radiophysics and Electronics of National Academy of Ukraine, Ukraine*
- **Michel Ney,** *Département Micro-Ondes, Lab-STICC/Telecom Bretagne, Technopôle Brest-Iroise, CS 83818, 29238 Brest Cedex 3, France*
- **Gerard Granet,** *Institut Pascal UMR 6602, Blaise Pascal University 24, av. des Landais, BP 80026, Aubière Cedex, 63177, France*
- **Konstantin Sirenko,** *O.Ya. Usikov Institute for Radiophysics and Electronics of National Academy of Sciences of Ukraine, 12, Ak. Proskura st., Kharkiv, 61085, Ukraine*

15:15 - 15:30	**- Non-covariance and Unfaithfulness in Projective Spacetime Transformation Optics** • **Robert Thompson,** *Karlsruhe Institute of Technology, Germany* • **Mohsen Fathi,** *Payam Noor University, Iran* Developments in Transformation Optics (TO) have drawn heavily on ideas from general relativity. This motivates a line of inquiry that seeks a deeper, more rigorous understanding of the spacetime covariant formulation of electrodynamics in media, and generalized ideas from general relativity that can further enhance TO. We show that basing TO on the idea of metric transformations is not covariant and introduces distortions to the desired behaviour of a light beam, but that these issues can be resolved by keeping the metric fixed.	**Integrated Gold Dimer For Efficient Tweezing And Sensing Of A Single Submicrometric Object** • **Aurore Ecarnot,** *C2N Orsay/Université Paris Sud, France* • **Giovanni Magno,** *C2N Orsay/Université Paris Sud, France* • **Vy Yam,** *C2N Orsay/Université Paris Sud, France* • **Philippe Gogol,** *C2N Orsay/Université Paris Sud, France* • **Robert Mégy,** *C2N Orsay/Université Paris Sud, France* • **Béatrice Dagens,** *C2N Orsay/Université Paris Sud, France* We propose a new nanoparticle sensor based-on integrated all-optical trapping and detection. With a plasmonic dimer, we push the nanoobject trapping size down to 100 nm while providing information about the capturing event and the object size.
15:30 - 17:30	**COFFEE BREAK AND POSTER SESSION (WEDNESDAY AFTERNOON)**	
15:30	**POSTER SESSION** Session chairperson: Mirko Barbuto	

- **Yuriy Sirenko,** *L.N. Gumilyov Eurasian National University, 2, Satpayev st., Astana, 010008, Kazakhstan*
- **Hanna Sliusarenko,** *O.Ya. Usikov Institute for Radiophysics and Electronics of National Academy of Sciences of Ukraine, 12, Ak. Proskura st., Kharkiv, 61085, Ukraine*

New rigorous approaches to the analysis of 2-D photonic crystals with the "defects", playing the role of the various resonant waveguide elements, are suggested in the paper. Several simple problems demonstrating the effectiveness of the proposed approaches and their potential for obtaining reliable results for theoretical and practical applications have been solved.

4 - Polarization-dependent Color Filters Based On All-dielectric Metasurfaces For Dynamic Modulation Of Color HSV

- **Tao Ze,** *Huazhong University of Science and Technology, China*

Here, we propose three kinds of color filters based on all-dielectric metasurfaces to control color hue, saturation and value (HSV) at the visible region, respectively. Designed with principle of magnetic resonances and structural anisotropy, the output of proposed color filters could be dynamically modulated by changing polarization state of light.

5 - Half Mode Substrate Integrated Waveguide (HMSIW) Notch Filters using Open Ring Resonators

- **Juan Hinojosa,** *Universidad Politécnica de Cartagena, Spain*
- **Marcello Rossi,** *Universidad Politécnica de Cartagena, Spain*
- **Alejandro Alvarez-Melcon,** *Universidad Politécnica de Cartagena, Spain*
- **Félix Lorenzo Martínez-Viviente,** *Universidad Politécnica de Cartagena, Spain*

An open ring resonator (ORR) is applied to a half mode substrate integrated waveguide (HMSIW) for the design of notch filters. This ORR cell is connected in parallel with a HMSIW section. The measured ORR-loaded HMSIW has the same behavior as a shunt series LC resonant circuit with a 3 dB stop-band bandwidth lower than 5 % and insertion loss above 15 dB. This ORR cell can be useful for the design of higher-order band-stop filters and reconfigurable HMSIW band-stop filters by placing a varactor diode connected to the open ring resonator.

Wednesday

6 - Ferromagnetic Resonance in Fibonacci-modulated Magnetic Metamaterials

- Tomomi Suwa, *Nara Institute of Science and Technology, Japan*
- Satoshi Tomita, *Nara Institute of Science and Technology, Japan*
- Toshiyuki Kodama, *Nara Institute of Science and Technology, Japan*
- Nobuyoshi Hosoito, *Nara Institute of Science and Technology, Japan*
- Hisao Yanagi, *Nara Institute of Science and Technology, Japan*

Magnetic multilayers with Fibonacci sequence, referred to as magnetic Fibonacci-modulated multilayers (FMMs), are prepared using ultra-high vacuum vapor deposition. Experimental results by in-situ reflection high energy electron diffraction and ferromagnetic resonance demonstrate that the epitaxially-grown FMMs have quasi-isotropic magnetization.

7 - Stern-Gerlach Effects for Microwaves by Nonuniform Chiral Metamaterials

- Satoshi Tomita, *Nara Institute of Science and Technology, Japan*
- Kei Sawada, *RIKEN SPring-8 Center, Japan*
- Shotaro Nagai, *Yamaguchi University, Japan*
- Atsushi Sanada, *Osaka University, Japan*
- Nobuyuki Hisamoto, *Kyoto Institute of Technology, Japan*
- Tetsuya Ueda, *Kyoto Institute of Technology, Japan*

Nonuniform chiral metamaterials with a refractive index gradient are embodied using the chiral meta-atoms that exhibit optical activities at microwave frequencies. We have succeeded in observing the Stern-Gerlach effects for microwaves by the nonuniform chiral metamaterials.

8 - Surface-phonon polaritons appearing on the surface of SiC and the potential of their interaction with surface-plasmon polaritons

- Kenichi Kasahara, *Ritsumeikan University, Japan*
- Yuhto Yamamoto, *Ritsumeikan University, Japan*
- Jyunichi Miyata, *Ritsumeikan University, Japan*
- Nobuyuki Umemori, *Ritsumeikan University, Japan*
- Toyonari Yaji, *Ritsumeikan University, Japan*
- Nobuhiko Ozaki, *Wakayama University, Japan*
- Naoki Ikeda, *National Institute for Materials Science, Japan*
- Yoshimasa Sugimoto, *National Institute for Materials Science, Japan*

Circular slot antennas were formed in an array on the surface of SiC. Surface phonon polariton signals were investigated by changing the distance between the neighboring antennas. It was possible that surface plasmon polaritons, in which electrons have a role, produced an effect on the spectral transformation.

9 - PT symmetry in a quasi-periodic structure with topological edge modes Poster [Hide abstract]

- Nicolas Rivolta, *University of Mons, Belgium*
- Henri Benisty, *Institut d'optique Graduate School, France*
- Bjorn Maes, *University of Mons, Belgium*

We report on an investigation of topological features of a 1D photonic crystal within the PT symmetry context. We use the scattering characteristics to analyze the various properties of this structure. Quasi-periodicity induces the presence of bandgaps in the spectrum. Topology-dependent interface modes are induced in such gaps by a specific back-to-back arrangement. The behaviour of these interface modes still displays a non trivial dependence on the crystal, even in a passive system. On this basis, the addition of gain and loss generates another layer of complexity, with intriguing mode-merging behaviours, anisotropic transmission resonances and lasing effects.

10 - Fano Resonance Excitations In Slanted Hyperbolic Cavities

- Fabio Vaianella, *UMONS, Belgium*
- Bjorn Maes, *UMONS, Belgium*

Fano resonances are asymmetric line-shape scattering phenomena that arise from the interplay between a slowly varying background and a narrow resonant process. We show the possibility to excite Fano features in multilayered hyperbolic metamaterials based on a central slanted section. This work could be useful for sensing applications.

11 - Analytical solutions for waves in spherically- and cylindrically-symmetric inhomogeneous media

- Andrey Novitsky, *Technical University of Denmark, Denmark*
- Alexander Shalin, *ITMO University, Russia*
- Andrei Lavrinenko, *Technical University of Denmark, Denmark*

We present the operator approach of finding material parameters of inhomogeneous bianisotropic media, the Maxwell equations in which have closed-form solutions. It is applicable to spherically- and cylindrically-symmetric media. Scattering theory for the inhomogeneous objects in question is developed.

12 - Modal Analysis of Meta Atoms using a Transfer Matrix Approach

- Radius Nagassa Setyo Suryadharma, *Karlsruhe Institute of Technology, Germany*
- Martin Fruhnert, *Karlsruhe Institute of Technology, Germany*
- Ivan Fernandez-Corbaton, *Karlsruhe Institute of Technology, Germany*
- Carsten Rockstuhl, *Karlsruhe Institute of Technology, Germany*

The knowledge of how meta-atoms couple to each other can significantly improve the understanding of their optical response and, in general, of metamaterials made from an assembly of meta-atoms. Here, we concentrate on identifying the eigenmodes of the transfer matrix of the meta-atom. The coupling between several meta-atoms can be conveniently investigated using their transfer matrices in coordinate systems local to each meta-atom. This provides a way to study effects of hybridization beyond the dipole and the quasi-static approximation for arbitrary meta-atoms. We concentrate here on meta-atoms that can be fabricated by self-assembly and bottom-up strategies.

13 - Plasmon-Polariton Gap Soliton Transparency in 1D Kerr-Metamaterial Superlattices

- Tiago P. Lobo, *Universidade Federal de Alagoas, Brazil*
- Luiz Eduardo Oliveira, *Instituto de Fisica, Universidade Estadual de Campinas, São Paulo, Brazil*
- Solange B. Cavalcanti, *Universidade Federal de Alagoas, Brazil*

Plasmon-polariton (PP) gap soliton formation and transparency switching in nonlinear systems composed of alternate layers of Kerr material/dispersive linear metamaterial are theoretically studied. The influence of a defocusing nonlinearity on the transmission switching phenomenon is analized, revealing different effects in the top and bottom edges of the PP gap.

14 - Sinusoidal in Shaped Graphene Plasmonic Metasurfaces

- Shahnaz Aas, *Bilkent University, Turkey*
- Humeyra Caglayan, *Nanotechnology Research Center, Bilkent University, Turkey*
- Ekmel Ozbay, *Nanotechnology Research Center, Bilkent University, /t*

In this work, we designed graphene nanoribbons (GNRs) with sinusoidal edges. We compared experimentally and theoretically the plasmonic properties for this structure to the GNRs with straight edges. Simulation results show very high enhancement of electric field intensity at the edges of the Shaped GNRs in comparison with the edges of GNRs. Moreover, we investigated the shift of the wavelength of the plasmonic resonance for the Shaped-GNRs compared to the straight GNRs with the same period. Plasmonic resonance tuning with electrical doping is more for Shaped GNRs than the GNRs.

15 - Sound Transmission Loss of a Locally Resonant Metamaterial using the Hybrid Wave Based - Finite Element Unit Cell Method

- Lucas Van Belle, *KU Leuven, Department of Mechanical Engineering, Belgium*
- Elke Deckers, *KU Leuven, Department of Mechanical Engineering, Belgium*
- Claus Claeys, *KU Leuven, Department of Mechanical Engineering, Belgium*
- Wim Desmet, *KU Leuven, Department of Mechanical Engineering, Belgium*

This paper discusses the sound transmission loss of a locally resonant metamaterial, by application of the hybrid Wave Based - Finite Element unit cell method. Since damping has an important influence on the vibro-acoustic attenuation performance of these metamaterials, the impact of damping in resonator and host structure on the sound transmission loss is examined.

16 - CRLH Metamaterial Transmission Line Based-Wideband Planar Antenna for Operation Across UHF/L/S-bands

- **Mohammad Alibakhshikenari,** *Electronic Engineering Department, University of Rome "Tor Vergata", Rome, ITALY, ITALY*
- **Ernesto Limiti,** *Electronic Engineering Department, University of Rome "Tor Vergata", Rome, ITALY, ITALY*
- **Bal Singh Virdee,** *London Metropolitan University, Center for Communications Technology, Faculty of Life Sciences and Computing, London N7 8DB, UK, UK*
- **Lotfollah Shafai,** *Electrical and Computer Engineering, University of Manitoba, Winnipeg, MB, CANADA, CANADA*
- **Aurora Andújar,** *Technology Department, Fractus, Barcelona, SPAIN, SPAIN*
- **Jaume Anguera,** *Fractus and Electronics and Communications Dept., Universitat Ramon Llull, Barcelona, SPAIN, SPAIN*

The paper presents a miniature wideband antenna using CRLH-TL metamaterial. The proposed planar antenna has a fractional bandwidth of 100% and is designed to operate in several frequency bands from 0.8-2.4GHz. The antenna has a size of 14 6 1.6mm3. The peak gain and efficiency of the antenna are 1.5dBi and -75%.

17 - Low index plasmonics using air-like aerogels

- **Changwook Kim,** *Yonsei University, Korea (South)*
- **Dongheok Shin,** *Yonsei University, Korea (South)*
- **Seunghwa Baek,** *Yonsei University, Korea (South)*
- **Kyoungsik Kim,** *Yonsei University, Korea (South)*

We present the ultra-low index plasmonic sensor using air-like aerogel substrate. Aerogel is a nano-porous solid whose tiny pores effectively recognized effective medium in visible through near infrared spectra. Using high porous aerogel with air-like refractive index, we observe the enhanced sensitivity of the localized surface plasmonic resonance.

18 - Miniaturized plasmonic resonators based on hyperbolic wires

- **Rafik Smaali,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France*
- **Fatima Omeis,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France*
- **Antoine Moreau,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France*
- **Emmanuel Centeno,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France*
- **Thierry Taliercio,** *Université Montpellier,CNRS, IES, UMR 5214, F-34000, Montpellier, France, France*

We propose the concept of hyperbolic metamaterial wires allowing to miniaturize plasmonic resonators sustaining bulk plasmon polaritons squeezed in 1/100 of the wavelength. These new structures outperform the conventional Metal – Insulator –Metal optical antennas in terms of efficiency and miniaturization. A model is provided to scale the resonant wavelength by controlling the filling ratio between the metal and dielectric layers.

19 - Integration of Magnetic Plasmonic Nanoantennas On a Silicon Chip

- **Javier Losada ,** *Valencia Nanophotonics Technology Center (NTC), Spain*
- **Carlos García-Meca,** *Valencia Nanophotonics Technology Center (NTC), Spain*
- **Alejandro Martínez,** *Valencia Nanophotonics Technology Center (NTC), Spain*

Subwavelength plasmonic nanoantennas are key elements in nanophotonics, with application prospects in multiple disciplines. Here we show that magnetic (sandwich) nanoantennas can be efficiently integrated on a silicon chip and properly fed by using the TM mode of the waveguide at telecom wavelengths.

20 - Electrodynamic Properties of Photonic Hypercrystal Formed by a Hyperbolic Metamaterials with Ferrite and Semiconductor Layers

- **Illia Fedorin,** *National Technical University Kharkiv Polytechnic Institute, Ukraine*

Electrodynamic properties of a hypercrystal formed by periodically alternating two types of anisotropic metamaterials is studied for the case, when an external magnetic field is applied parallel to the boundaries of the layers. An effective medium theory which is suitable for calculation of properties of long-wavelength electromagnetic modes is applied in order to derive averaged expressions for effective constitutive parameters. It has been shown that providing a conscious choice of the constitutive parameters and material fractions of magnetic, semiconductor, and dielectric layers, the system under study shows hypercrystal properties for both TE and TM waves in the different frequency ranges.

21 - Multiple Exceptional Rings in an Acoustic Metamaterial Made by Spinning Cylinders

- **Yao-Ting Wang,** *University of Birmingham, United Kingdom*
- **Kin-Hung Fung,** *The Hong Kong Polytechnic University, Hong Kong*
- **Degang Zhao,** *Huazhong University of Science and Technology, China*
- **Shuang Zhang,** *University of Birmingham, United Kingdom*
- **Zhao-Qing Zhang,** *Hong Kong University of Science and Technology, Hong Kong*
- **C. T. Chan,** *Hong Kong University of Science and Technology, Hong Kong*

We show that multiple exceptional rings can exist in an acoustic metamaterial. As the phenomenon occurs under long-wavelength limit, effective medium theory can be applied to obtain effective material indices in the scatterers. With the aid of effective indices, an effective Hamiltonian is also calculated.

22 - Frequency-Controlled Beam Scanning Array Fed by Spoof Surface Plasmon Polaritons

- **Jia Yuan Yin,** *Southeast University, China*
- **Tie Jun Cui,** *Southeast University, China*

We propose frequency-controlled broadband and broad-angle beam scanning array based on spoof surface plasmon polaritons (SPPs). The conventional planar spoof SPP waveguide consisting of double-sided corrugated unit cells is split into two branches. After being split, each spoof SPP waveguide branch is used to feed a row of circularly metallic patches for radiations. The proposed structure can realize wide-angle beam scanning from backward direction to forward direction as the frequency changes, breaking the limit of traditional leaky-wave antennas. It is shown that the scanning angle can reach 93 degrees with an average gain level of 9.6 dBi.

23 - Enhancement Of Second Harmonic Generation In Semi Conductors III-V Using One Dimensional Photonic Crystal

- **Amani Cheriguene,** *Laboratoire d'Etude des Matériaux (LEM),University of Mohammed Seddik Ben Yahia, Algeria*
- **Hachemi Bouridah,** *Laboratoire d'Etude des Matériaux,University of Mohammed Seddik Ben Yahia, Algeria*
- **Mahmoud Riad Beghoul,** *Laboratoire d'Etude des Matériaux,University of Mohammed Seddik Ben Yahia, Algeria*

In this work, the optimization of one dimensional photonic crystal (PCs) for second harmonic generation (SHG) in semiconductors III-V was theoretical studied. The effects of the photonic structure periodicity at the photonic band gap (PBG) edges on the slowing down of light and enhancement of SHG were discussed. The phase matching and group velocity curves were modeled using the Plane-Wave Expansion method (PWE). Results show the singularities of the nonlinear effects in these structures. The plane wave method was extended to calculate the local field factor at both the fundamental light and the second harmonic. The enhancement factor of SHG predicted in these structures can be up to 10e8.

24 - Localized Surface Plasmon Resonance of Magneto-optic Rods

- **Yaxian Ni,** *Soochow University, China*
- **Hua Sun,** *Soochow University, China*

We apply the Mie scattering theory to analyzed the resonance condition and the features of both the far-field and the near-field at resonance for cylindrical magneto-optical particles. Based on this model the effects of particle size on the resonance peaks are also discussed.

25 - Vibroacoustic Behavior Of A Pre-fractal Distribution in A Sandwich Structure

- **Jérémie Derré,** *Office National d'Etudes et de Recherches Aérospatiales, France*
- **Frank Simon,** *Office National d'Etudes et de Recherches Aérospatiales, France*

Sandwich trim panels are well-known materials in aircraft cabin. To increase their acoustic Transmission Loss, the authors propose to introduce masses within honeycomb core with a pre-fractal distribution. This paper shows numerical simulations and experiments on the vibroacoustic behavior of a sandwich beam with self-similar pattern like Cantor set.

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26 - Compensation of loss-induced beam broadening in HMMs by a mu-negative HMM

- Taavi Repän, *DTU Fotonik, Technical University of Denmark, Denmark*
- Andrey Novitsky, *DTU Fotonik, Technical University of Denmark, Denmark*
- Morten Willatzen, *DTU Fotonik, Technical University of Denmark, Denmark*
- Andrei Lavrinenko, *DTU Fotonik, Technical University of Denmark, Denmark*

Losses play a crucial role when realistic hyperbolic metamaterials are considered. Importantly, losses lead to a broadening of beams propagating through a hyperbolic medium. Here we show that a part of the loss-induced broadening can be attributed to phase accumulation of plane-wave components. This phase accumulation can be canceled out by utilizing hyperbolic media with a negative permeability.

27 - Homogeneous Model for Regular and Irregular Metallic Wire Media Samples

- Sergei Kosulnikov, *ITMO University, Russia*

This work is devoted to analysis of the wire media sample based structures as homogeneous material with extreme permittivity tensor properties. One proves here that a heuristical model of a wire medium sample can be introduced for a new type of metamaterial - irregularly stretched wire medium-based sample. Our analysis includes a qualitative numerical model also answering to fundamental physical questions about dispersion characteristics of new metamaterial.

28 - Cloak, Anticloak, Magnification and Illusion in Magnetostatics

- Rosa Mach-Batlle, *Universitat Autonoma de Barcelona, Spain*
- Albert Parra, *Universitat Autonoma de Barcelona, Spain*
- Sergi Laut, *Universitat Autonoma de Barcelona, Spain*
- Carles Navau, *Universitat Autonoma de Barcelona, Spain*
- Nuria Del-Valle, *Universitat Autonoma de Barcelona, Spain*
- Alvaro Sanchez, *Universitat Autonoma de Barcelona, Spain*

We theoretically demonstrate how cloaks, anticloaks, magnifiers and illusion devices can be designed for the case of static magnetic fields. For some of these devices, we make use of the concept of negative permeability materials. Because these materials can be emulated in practice by sets of currents, our results may provide the recipe for the experimental realization of novel devices for controlling magnetic fields.

29 - High-Index All-Dielectric Optical Metasurfaces With Broken Vertical Symmetry

- Florian Dubois, *Institut des Nanotechnologies de Lyon, France*
- Hai Son Nguyen, *Institut des Nanotechnologies de Lyon, France*
- Thierry Deschamps, *Institut des Nanotechnologies de Lyon, France*
- Xavier Letartre, *Institut des Nanotechnologies de Lyon, France*
- Jean-Louis Leclercq, *Institut des Nanotechnologies de Lyon, France*
- Christian Seassal, *Institut des Nanotechnologies de Lyon, France*
- Pierre Viktorovitch, *Institut des Nanotechnologies de Lyon, France*

In this presentation we study high-contrast gratings (HCGs) characterized by a vertical asymmetry. These structures exhibit specific dispersions like zero-curvature flat-bands (referred as ultra-flat bands) and linear dispersions at the center of the first Brillouin zone (so-called Dirac cones). We investigate the origin of these particular dispersions using temporal coupled modes theory and RCWA simulations. It turns out that the vertical symmetry breaking of the structure is the key feature that explains these particularities.

30 - Gradient effective medium model for inhomogenous nanoparticle layers

- Krzysztof Czajkowski, *University of Warsaw, Poland*
- Dominika Świtlik, *University of Warsaw, Poland*
- Tomasz Antosiewicz, *University of Warsaw, Poland*

We present a gradient effective permittivity model in which the nanoparticle layer is homogenized into sublayers, whose permittivities depend on the spatial distribution of nanoparticles. The model is applied to simulate a plasmonic sensor covered by a nanoparticle layer. The results with effective gradient layers are consistent with rigorous simulations.

31 - Graphene-based optically switchable single and dual-band terahertz modulators

- Alexander Grebenchukov, *ITMO University, Russia*
- Anton Zaitsev, *ITMO University, Russia*
- Mikhail Novoselov, *ITMO University, Russia*
- Egor Kornilov, *ITMO University, Russia*
- Mikhail K. Khodzitsky, *ITMO University, Russia*

The optically switchable graphene-based modulators for terahertz frequencies were proposed and investigated. The modulators structure consists of cross-shaped aluminium metasurface covered by graphene monolayer. By using graphene surface conductivity theory and full electromagnetic wave simulations the switching of one or two resonant high-Q dips in transmission spectra by infrared optical pumping were demonstrated. The proposed modulators can beused in the sensing applications and high-speed communications.

32 - A Classification Of The Modes Present In High Epsilon Dielectric Wire Media

- Taylor Boyd, *Cockcroft Institute, United Kingdom*
- Rosa Letizia, *Lancaster University, Italy*
- Jonathan Gratus, *Lancaster University, United Kingdom*
- Paul Kinsler, *Lancaster University, New Zealand*

We have confirmed the existence of longitudinal modes in a wire medium of high epsilon thin rods. The dispersion relation of these modes has been found to be plasma-like allowing them to be manipulated by changing the structural parameters of the wire media. Our research in this area was inspired by the theoretical work done into metal wire media and became an extension of their analysis to dielectric wire media, which leads to potential uses in mode profile shaping applications.

33 - Design of a Remote Control Mach-Zehnder Switch using Transformation Optics

- David Margousi, *University of Shahre-Rey, Iran*
- Hamed Reza Shoorian, *University of Torbate-e-Heydarieh, Iran*
- Reza Rezapour, *University of Torbate-e-Heydarieh, Iran*

Based on transformation optics, in this paper a new method is introduced to design a remote control Mach-Zehnder switch. In the presence of an illusion device enabled by metamaterials, the effective refractive index of a certain length of one of Mach-Zehnder arms is remotely changed to produce needed phase differences.

34 - Analysis of graphene based polarization-selective metasurfaces with equivalent conductivity method

- Mohammad Danaeifar, *Center of Excellence in Electromagnetics, Faculty of Electrical Engineering, K. N. Toosi University of Technology, Iran*
- Nosrat Granpayeh, *Center of Excellence in Electromagnetics, Faculty of Electrical Engineering, K. N. Toosi University of Technology, Iran*

In this paper, an analytical approach is provided to analyze and synthesize the homogeneous and inhomogeneous metasurfaces consisting of asymmetric meta-atoms. The meta-atoms have different optical properties with respect to various field directions of the incident waves. Also, we synthesize a graphene based polarization-selective metasurface as an example of the possible applications. The calculated results are confirmed by numerical full-wave simulations.

35 - Experiments on three-dimensional metallic metamaterials

- Junhee Park, *University of California, San Diego, USA*
- Ashok Kodigala, *University of California, San Diego, USA*
- Abdoulaye Ndao, *University of California, San Diego, USA*
- Boubacar Kante, *University of California, San Diego, USA*

The hybridization of plasmon modes in a multilayered structure composed of gold bars are experimentally shown to exhibit inversion between their hybridized modes in the near-infrared domain. Moreover, experimentally, the decay (radiation) rates of plasmonic modes are quantitatively estimated.

36 - Enhancing backscattering from the back contact using metallic nanostructures for efficient perovskite solar cells

- Omar A. M. Abdelraouf, *Energy Materials Laboratory (EML), Department of Physics, School of Sciences and Engineering, The American University in Cairo, New Cairo 11835, Department of Eng. Physics and Mathematics, Faculty of Eng., Ain Shams University, Cairo 11517, Egypt*

Wednesday

- **Ahmed Shaker,** *Department of Eng. Physics and Mathematics, Faculty of Eng., Ain Shams University, Cairo 11517, Egypt*
- **Nageh K. Allam,** *Energy Materials Laboratory (EML), Department of Physics, School of Sciences and Engineering, The American University in Cairo, New Cairo 11835, Egypt*

Perovskite ($CH_3NH_3PbI_3$) solar cells are attracting more attention in last decade due to rapid development in its energy conversion efficiency and material properties. Herein, we investigate possibility of enhancing the amount of reflected light from the back contact using silver nanostructures deposited on the back contact. Using the principles of Mie's theory, we calculate the backscattering cross section for many shapes/dimensions of silver nanostructures. The simulation results suggest that certain structures could enhance the backscattering while others will reduce it. Based on the results of this work, we could enhance the light confinement in the active layer of the solar cell, hence increase the overall efficiency of perovskite solar cells.

37 - Tunable Piezoelectric Phononic Crystal Plates

- **Nesrine Kherraz,** *University of Le Havre, LOMC UMR CNRS 6294, France*
- **Bruno morvan,** *University of Le Havre, LOMC UMR CNRS 6294, France*
- **Lionel Haumesser,** *University François-Rabelais of Tours, GREMAN UMR CNRS 7347, France*
- **Marco Miniaci,** *University of Le Havre, LOMC UMR CNRS 6294, France*
- **Reveka Sainidou,** *University of Le Havre, LOMC UMR CNRS 6294, France*
- **Pascal Rembert,** *University of Le Havre, LOMC UMR CNRS 6294, France*
- **Franck Levassort,** *University François-Rabelais of Tours, GREMAN UMR CNRS 7347, France*

Propagation of guided Lamb waves in a piezoelectric phononic plate. The application of Electric Boundary Conditions (EBCs) induces some changes in the effective elastic properties of the plate. More particularly, the case of inductive impedance charges connected on the PC is investigated. This configuration enables the creation of low-frequency gap in the sub-wavelength regime.

38 - Broadband Huygens Sources Made of Spherical Nanoclusters for Metasurfaces Applications

- **Romain Dezert,** *Centre de Recherche Paul Pascal, France*
- **Philippe Richetti,** *Centre de Recherche Paul Pascal, France*
- **Alexandre Baron,** *Centre de Recherche Paul Pascal, France*

We present spherical clusters, composed by spherical dielectric inclusions, as a new kind of efficient and broadband Huygens sources. We show that this design allows a large and multimode overlapping of the electric and magnetic resonances and is versatile enough so that several materials may be used as inclusions. They may serve as constitutive elements to develop highly efficient and high transmittance metasurfaces and are particularly suited to bottom-up fabrication and self-assembly

39 - MultiBand Compact Frequency Selective Surface Based on Modified Loop and Parasitic Patch

- **A. Nooraei Yeganeh,** *K. N. Toosi University of Technology, Iran*
- **H. Nasrollahi ,** *Imam Khomeini International University, Iran*
- **S. H. Sedighy,** *Iran University of Sciecne and Tech. , Iran*
- **S. Mohammad-Ali-Nezhad ,** *University of Qom, Iran*

A multiband compact band stop frequency selective surface (FSS) is proposed based on modified square loop structures with parasitic patches which can work at L, C and X bands, simultaneously. A major capacitor created between loop and parasitic patches as well as parallel inductors and added stubs achieve this multiband behavior. A triple bands structure is designed and simulated to demonstrate the idea which works at 3GHz, 5.3GHz and 11 GHz independent from the polarization of incident wave. Moreover the proposed structure has a small size equal to 0.095 0.095 c2 where c is the free space wavelength. Flexibility in multiband tuning, simplicity and compact size candidate this FSS a good choice for multiband applications.

40 - Triple-Bands Ka-Band Metasurface Filter with Different Polarized Outputs in Each Band

- **M. Sharifian Mazraeh Mollaei,** *Iran University of Sciecne and Tech. , Iran*
- **S.H. Seidghy,** *Iran University of Sciecne and Tech. , Iran*

A triple-bands metasurface filter composed of combined enhanced Jerusalem and Gangbuster unit cells over square substrate integrated waveguide cavities is presented. The enhanced Jerusalem cells produce two pass-bands with rotated polarization outputs while the enhanced Gangbuster one produces one pass-band with same polarized outputs in comparison with the input wave polarization. The pass-bands of the proposed metasurface are at 33.5 GHz, 35.1GHz and 36.8 GHz. The simulation results verify the proposed idea ability and capability.

41 - Random Lasing Emission And Active Control Of DCM-Doped PMMA Random Lasers

- **Bhupesh Kumar,** *Department of Physics, The Jack and Pearl Resnick Institute for Advanced Technology, Bar-Ilan University, Israel*
- **Yossi Abulafia,** *Department of Physics, The Jack and Pearl Resnick Institute for Advanced Technology, Bar-Ilan University, Israel*
- **Mélanie Lebental ,** *Laboratoire de Photonique Quantique et Moleculaire, ENS Cachan, France*
- **Patrick Sebbah,** *Department of Physics, The Jack and Pearl Resnick Institute for Advanced Technology, Bar-Ilan University; Institut Langevin, ESPCI ParisTech, Israel and France*

Random lasing is reported in solid state PMMA-DCM doped 1D organic microstructure with randomly distributed grooves along the length of polymer strip. Role of disorder which is provide by randomly distributed 100 nm grooves along the length of polymer strip is shown by the variation in emission spectra of random laser with local pump position

42 - Monopole Antenna Gain Enhancement by Using Layered Dielectrics Effective Medium

- **M. Sharifian Mazraeh Mollaei,** *Iran University of Sciecne and Tech., Iran*
- **S.H. Seidghy,** *Iran University of Sciecne and Tech., Iran*

Gain enhancement of a monopole antenna is proposed by adding cylindrical shell shaped dielectric layers around it as effective medium. By modifying the electrical field phases transmitted through the layers, the antenna gain can be enhanced. In order to produce the same phased field, the effective dielectric permittivity of this effective medium in each point is controlled by trimming cylindrical shells of the dielectric. This effective medium is composed of stacked cylindrical dielectric layers with same relative dielectric permittivity but different thicknesses. Implementing this method prove more than 80 % gain enhancement in monopole antenna.

43 - A Computational Floquet-Bloch Homogenization Approach For Modeling Nonlocal Scattering Effects In Acoustic Metamaterials

- **Ashwin Sridhar,** *Eindhoven University of Technology, Netherlands*
- **Varvara Kouznetsova,** *Eindhoven University of Technology, Netherlands*
- **Marc Geers,** *Eindhoven University of Technology, Netherlands*

A novel computational multiscale approach based on Floquet-Bloch theory for modeling 2D/3D acoustic metamaterials exhibiting nonlocal scattering effects is presented. The technique is validated by comparing the dispersion spectrum of an example unit cell design obtained using the homogenized model at different solution orders to direct numerical simulation.

44 - High Performance Waveguide Array Antenna by Using Artificial Magnetic Conductor Metasurface

- **S.H. Esmaeli,** *Iran University of Sciecne and Tech. , Iran*
- **S. H. Seidghy,** *Iran University of Sciecne and Tech. , Iran*

A high performance waveguide slot array antenna by using artificial magnetic conductor metasurfaces is proposed. While one type of AMC metasurfaces mounted at the waveguide broad side walls modify the current distribution at the waveguide broad wall to achieve collinear configuration with low side lobe level and high gain, the other AMC type changes the reflection phase from the back and end walls PEC termination to compact the antenna structure. The simulation results prove that the proposed idea results in 6 dB SLL reduction, 1.8 dB gain enhancement and about 15 % compactness compared with conventional Elliot one.

45 - Numerical Method to Study Three-Dimensional Metamaterial Composites

- **Takamichi Terao,** *Gifu university, Japan*

A generalized plane-wave expansion (G-PWE) method was developed to solve Maxwell's equations for the propagation of electromagnetic waves. This method is applicable to dispersive materials with arbitrary frequency-dependent permittivity and permeability, where such features are requisite to investigate the electromagnetic wave propagation in metamaterials and their composites.

46 - Enhanced Electromagnetic Transmission by Metamaterial Antireflection Coating for Ground Penetrating Radar Applications

- **Tong Hao,** *Tongji University, China*
- **Wenyu Zhang,** *Tongji University, China*

In this paper we present our simulation results of two metamaterial antireflection coating designs for ground-coupled and air-coupled Ground Penetrating Radar applications. The traditional Split ring resonator (SRR) and the proposed Closed ring resonator (CRR) both show near perfect antireflection, and the enhanced transmittance is only limited by the losses of the coating itself. By geometrical optimization, the CRR based antireflection coating has been numerically demonstrated to enhance the transmittance by 34% compared to there is no such coating.

47 - Nonlinear Optical Response of Chalcogenide Glassy Semiconductors in the IR and THz Ranges Studied with the Femtosecond Resolution in Time

- **Elena Romanova,** *Saratov State University, Russia*
- **Stephane Guizard,** *CNRS-Ecole Polytechnique, France*
- **Tianwu Wang,** *Technical University of Denmark, Denmark*
- **Peter Uhd Jepsen,** *Technical University of Denmark, Denmark*
- **Andrei Lavrinenko,** *Technical University of Denmark, Denmark*
- **Zuoqui Tang,** *University of Nottingham, United Kingdom*
- **Angela Seddon,** *University of Nottingham, United Kingdom*
- **Trevor Benson,** *University of Nottingham, United Kingdom*

Two time-resolved experimental methods have been used for characterization of the non-linear optical response of chalcogenide glasses of the system As-S-Se-Te in IR and THz ranges upon excitation by femtosecond laser pulses at 800 nm wavelength. Photoinduced conductivity and refractivity were studied by using a rate equation model.

48 - Dielectric metamaterial-based gradient index lens in the terahertz frequency range

- **Fabian Gaufillet,** *Université paris-sud - Institut d'Electronique Fondamentale, France*
- **Simon Marcellin,** *Université Paris-Sud - Institut d'Electronique Fondamentale, France*
- **Eric Akmansoy,** *Université Paris-Sud - Institut d'Electronique Fondamentale, France*

We have tailored the effective refractive index of dielectric metamaterials to design a flat lens operating at terahertz frequencies. The studied dielectric metamaterials consist of high permittivity resonators, whose first Mie resonance gives rise to resonant effective permeability. The resonance frequency is fixed by the size of the resonators. By varying this size, we could adjust the value of the resonance of the effective permittivity and, thereby, of the effective refractive index. Then, we fitted this one to the profile of refractive index of a graded index flat lens, of which we show that it focuses an incident plane wave at terahertz frequencies and that the spot in the focal plane is diffraction-limited. It is less than one and a half wavelength thick, its focal length is only a few wavelengths

49 - A Compact Notched Chamfered Rectangular Dielectric Resonator Antenna with Edge Grounding for Wide-band Application

- **Arpita Tandy,** *PDPM IIITDM, Jabalpur, India*
- **Monika Chauhan,** *PDPM IIITDM, Jabalpur, India*
- **Shubha Gupta,** *PDPM IIITDM, Jabalpur, India*
- **Biswajeet Mukherjee,** *PDPM IIITDM, Jabalpur, India*

In this paper, a compact rectangular dielectric resonator antenna has been introduced in which notched chamfered technique with the edge metal plate on one side of DRA is used to enhance the bandwidth. The probe feeding is used to excite the DRA as it can easily optimize by adjusting probe height and its location. The proposed antenna has a simulated impedance bandwidth of 81.53% from 3.9 to 9.2 GHz (S11 < -10 dB) shows wide frequency band and 3dB axial-ratio bandwidth of 13.16 % i.e. from 7.31 to 8.34 GHz. DRA is made up of dielectric constant 9.2 (Rogers TMM 10) with loss tangent tan = 0.0022. The main purpose of this paper is to reduce the size of DRA without any trade-off with its impedance bandwidth, gain and efficiency. Proposed design offers three different modes at three resonance frequencies, TM11 , TM01 , and TM21 modes at 4.1 GHz, 5.5 GHz and 7.07 GHz respectively.

50 - Waveguide and horn antennas manufactured using AM

- **Darren Cadman,** *Loughborough University, United Kingdom*
- **Shiyu Zhang,** *Loughborough University, UK*
- **Yiannis Vardaxoglou,** *Loughborough University, UK*
- **William Whittow,** *Loughborough University, UK*

We review how additive manufacturing (AM) can be deployed for the rapid prototyping of microwave waveguide componentry and antennas. Additive manufacture using fused deposition modelling of such objects allows new, novel and complex structures to be fabricated with lower impact on the environment relative to current manufacturing processes, plus the fast turnaround of design to manufacture and test. Additionally while the resulting physical antenna properties may not be perfect compared to the design or what can be machined, their RF/microwave performance can be quite forgiving thereby allowing the antenna design engineer to fully exploit the rapid prototyping concept.

51 - Modulation of Polarization Ellipticity of Terahertz Waves with Gate-controlled Graphene Metadevices

- **Soojeong Baek,** *Korea Advanced Institute of Science and Technology, Korea (South)*
- **Hyeon-Don Kim,** *Korea Advanced Institute of Science and Technology, Korea (South)*
- **Jagang Park,** *Korea Advanced Institute of Science and Technology, Korea (South)*
- **Kanghui Lee,** *Korea Advanced Institute of Science and Technology, Korea (South)*
- **Bumki Min,** *Korea Advanced Institute of Science and Technology, Korea (South)*

We suggested gated-controlled graphene metadevices where crossed I-type metamaterials and patterned graphene are coupled to modulate polarization ellipticity of THz waves. With the graphene-hybridized metadevices, only the phase difference of the two linearly polarized light beams can be controlled without changing the transmittance in the narrow frequency region.

52 - Direct Demonstration of Toroidal Response Excitation in Water Metamolecule

- **Nikita Pavlov,** *ITMO University, Russia*
- **Ivan Stenishchev,** *University of Science and Technology "MISiS", Russia*
- **Polina Kapitanova,** *ITMO University, Russia*
- **Pavel Belov,** *ITMO University, Russia*
- **Alexey Basharin,** *University of Science and Technology "MISiS", Russia*

In this paper, we theoretically and experimentally demonstrate the toroidal response in metamaterials based on water. The theoretical part is a calculated special configuration of the distribution of electromagnetic fields. This contribution is corresponding to the toroidal resonance. Also in this part we will show the numerical confirmation of the dominant toroidal multipole in a narrow frequency range – around 1 GHz. The experimental part is unique due to demonstrating electromagnetic fields both within a cluster and in a single metamolecule. The experimental data confirm the toroidal excitation in water metaclusters at the microwave frequency range in situ.

53 - Miniaturized Circuit Design of Operational-Amplifier-Based Non-Foster Impedance

- **Kenichi Matsumoto,** *Kansai University, Japan*
- **Toshiaki Kitamura,** *Kansai University, Japan*
- **Yasushi Horii,** *Kansai University, Japan*

Three types of operational-amplifier-based negative impedance converters (NIC) are demonstrated by the same circuit configuration but different circuit patterns designed on printed circuit board (PCB)Circuit simulations by ADS and measured results indicates that the frequency response of the negative capacitance becomes broader and the negative value approaches to the ideal one by designing the circuit super compact.

54 - Babinet's Principle For Plasmonic Antennas: Complementarity And Differences

- **Martin Hrto,** *Central European Institute of Technology, Brno, Czech Republic*
- **Vlastimil KŚápek,** *Central European Institute of Technology, Brno, Czech Republic*
- **Michal Horák,** *Central European Institute of Technology, Brno, Czech Republic*
- **Tomáš ŠamoŚil,** *Central European Institute of Technology, Brno, Czech Republic*
- **Filip Ligmajer,** *Central European Institute of Technology, Brno, Czech Republic*
- **Michael Stöger-Pollach,** *Vienna University of Technology, Austria*
- **Tomáš Šikola,** *Central European Institute of Technology, Brno, Czech Republic*

We study the Babinet-principle complementary plasmonic antennas (particles and apertures). Using theoretical simulations we show that both particles and apertures have similar energies of localized plasmon resonances and complementary near fields. On the other hand, experimental characterization by cathodoluminescence and electron energy loss spectroscopy reveals important differences, such as a better excitation efficiency for the apertures. We discuss the consequences for the application of the antennas in enhanced optical spectroscopy.

55 - Focusing Performance Of Luneburg Lenses Based On A Broadband Artificial Dielectric Metamaterial

- **Andrey Sayanskiy,** *ITMO University, Russia*
- **Valeri Akimov,** *Peter the Great St. Petersburg Polytechnic University, Russia*
- **Stanislav Glybovski,** *ITMO University, Russia*

In this work, we present the results of numerical investigation of the microwave Luneburg lenses based on a broadband metamaterial composed of radially diverging dielectric rods. The required spatially non-uniform permittivity is reached by engineering the local cross-section of radially diverging dielectric rods.

56 - Control of luminescence in resonant nanodiamonds with NV-centers

- **Anastasiia Zalogina,** *University of information technologies, mechanics and optics, Russia*
- **Georgiy Zograf,** *University of information technologies, mechanics and optics, Russia*
- **Elena Ushakova,** *University of information technologies, mechanics and optics, Russia*
- **Filipp Komissarenko,** *University of information technologies, mechanics and optics; St. Petersburg Academic University, Russia*
- **Roman Savelev,** *University of information technologies, mechanics and optics, Russia*
- **Sergey Kudryashov,** *University of information technologies, mechanics and optics; Lebedev Physical Institute Russian Academy of Science , Russia*
- **Sergey Makarov,** *University of information technologies, mechanics and optics, Russia*
- **Dmitriy Zuev,** *University of information technologies, mechanics and optics, Russia*
- **Pavel Belov,** *University of information technologies, mechanics and optics, Russia*

Resonant high-index nanostructures have demonstrated the unique opportunities for nanophotonic devices: surprising ways of emission manipulation at subwavelength scale, efficient control of radiation pattern, and low-losses. Here, the resonant properties of nanodiamonds with NV-centers in visible region were studied and the influence of resonance nature of nanodiamonds on the luminescence lifetime at zero-phonon line was demonstrated.

57 - Destruction of Symmetry Protected Optical Bound State in the Continuum by High-Index Substrate and Roughnesses

- **Andrey Bogdanov,** *ITMO University, Russia*

We experimentally and theoretically analyze the role of substrate on the optical bound states in the continuum (BICs). We reveal that a high-index substrate could destroy even in-plane symmetry protected BIC due to leakage into the diffraction channels opening in the substrate. We show how two concurrent loss mechanisms scattering due to surface roughness and leakage into substrate contribute to the suppression of the resonance lifetime.

58 - Self-Averaging Of The Effective Refractive Index And Anderson Localization Of Light

- **Roman Puzko,** *All-Russia Research Institute of Automatics; Moscow Institute of Physics and Technology, Russia*
- **Alexander Merzlikin,** *All-Russia Research Institute of Automatics; Moscow Institute of Physics and Technology;Institute for Theoretical and Applied Electromagnetics Russian Academy of Sciences, Russia*

The propagation of a plane wave through a layered system is considered in terms of the effective parameters. It is shown that the introduction of the effective wave vector beyond longwave approximation is correct and completely describes the Andeson localization of light. Moreover, we have shown that real and imaginary parts of the effective wave vector are connected by Kramers-Kronig like relations. These relations lead to the Herbert-Jones-Thouless relation

59 - Control of Light Propagation in Modified Semiconductor Bragg Mirrors with Embedded Quantum Wells]

- **Evgeny Sedov,** *Vladimir State University named after A.G. and N.G. Stoletovs, Russia*
- **Irina Sedova,** *Vladimir State University named after A.G. and N.G. Stoletovs, Russia*
- **Evgeniia Cherotchenko,** *University of Southampton, UK*
- **Alexey Kavokin,** *University of Southampton, UK*

Semiconductor Bragg mirrors with embedded quantum wells possess a hyperbolic dispersion of their eigen-modes that is typical for hyperbolic metamaterials. Their optical prop- erties are tuneable by changing the transmittance of embedded quantum wells by application of external bias. This enables to control the group velocity and refraction angle of light.

60 - Is It Possible to Replace an Isotropic Metafilm by a Homogeneous Layer ?

- **Zhanna Dombrovskaya,** *Lomonosov Moscow State University, Russia*
- **Anton Zhuravlev,** *Lomonosov Moscow State University, Russia*

We propose a new method for calculation of the effective thickness of an isotropic metafilm. We demonstrate that, if the absorption coefficient at particular wavelength is small enough (but not negligible), then silica glass metafilm can be replaced by an equivalent thin film. If the absorption is not small this replacement is not possible.

61 - Quantitative 3D Imaging of Metasurfaces Phase Response

- **JiŚ Babocký,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Aneta KŚižová,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Lenka Štrbková,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Lukáš Kejík,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Filip Ligmajer,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Martin Hrto,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Petr DvoŚák,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **MatŚj Tý,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Jana Śolláková,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Vlastimil KŚápek,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Radek Kalousek,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Radim Chmelík,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*
- **Tomáš Šikola,** *Central Eutopean Institute of Technology, Brno University of Technology, Czech Republic*

We report on investigation of phase-altering metasurfaces using Coherence-controlled holographic microscopy. We demonstrate its ability to obtain phase information from the whole field of view in a single measurement of a simple metasurface represented by a plasmonic zone plate.

62 - Time-resolved pump-probe measurement of optical rotatory dispersion in chiral metamaterial

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- **Jae Heun Woo,** *Ewha Womans University, Korea (South)*
- **Boyoung Kang,** *4Center for Advanced Meta-Materials, Korea (South)*
- **Minji Gwon,** *Ewha Womans University, Korea (South)*
- **Ji Hye Lee,** *Ewha Womans University, Korea (South)*
- **Dong-Wook Kim,** *Ewha Womans University, Korea (South)*
- **William Jo,** *Ewha Womans University, Korea (South)*
- **Dong Ho Kim,** *Yeungnam University, Korea (South)*

Transient optical rotatory power (ORP) is measured to clarify the temporal development of ORP by exciting d-band electrons to the conduction p-band of Au using a circularly polarized light (CPL) pump beam. Three distinct transient behaviors of ORP are identified, resulting from different energy relaxation processes of hot electrons that occur during a period of a few picoseconds after pumping. Nonthermal hot electrons experience the Lorentz force from an inverse Faraday effect and electron-boundary scattering, yielding a pump beam CPL helicity-dependent transient ORP. Once hot electrons are in thermal equilibrium with the lattice due to electron-lattice coupling, electron energy is distributed among the occupied states, as described by Fermi-Dirac statistics. Moreover, the transient ORP is found to be independent of pump beam CPL helicity, which is well explained by the selection rule of electron excitation and two-temperature model of the electron cooling process. Theoretical analysis of the transient ORP in terms of the energy relaxation of thermal hot electrons in CMM is carried out by introducing a temperature-dependent dielectric function and finite-difference time-domain simulation. It is found that the magnitude of ORP at an elevated temperature is reduced to less than that at room temperature, which agrees well with the experimental observation.

63 - A Metasolenoid-like Resonator for MRI Applications

- **Alena Shchelokova,** *ITMO Univercity, Russia*
- **Dmitry Dobrykh,** *ITMO Univercity, Russia*
- **Stanislav Glybovski,** *ITMO Univercity, Russia*
- **Irina Melchakova,** *ITMO Univercity, Russia*
- **Pavel Belov,** *ITMO Univercity, Russia*

In this work we propose and study via numerical simulation a new metamaterialinspired device for MRI. The proposed device is a one-dimensional periodic structure formed by multiple inductively-coupled split-loop resonators (SLRs). The whole structure at the resonance of its fundamental eigenmode has a homogeneous magnetic field in a hollow surrounded by the split-loops. It has been shown that the structure can be used as a wireless radio-frequency coil for magnetic resonance imaging (MRI) of a human arm located inside the SLRs. In order to tune the resonance to the operational (Larmor) frequency 63.8 MHz of a 1.5-Tesla scanner, each SLR was loaded to a structural capacity of printed metal strips.

64 - Plasmonic enhancement of silicon nanocrystals photoluminescence in the presence of gold nanowires

- **Sergey Dyakov,** *Skolkovo Institute of Science and Technology, Russia*
- **Denis Zhigunov,** *Moscow State University, Russia*
- **Olga Shalygina,** *Moscow State University, Russia*
- **Alexanders Marinins,** *KTH Royal Institute of Technology, Sweden*
- **Polina Vabishchevich,** *Moscow State University, Russia*
- **Sergei Popov,** *KTH Royal Institute of Technology, Sweden*
- **Nikolay Gippius,** *Skolkovo Institute of Science and Technology, Russia*
- **Sergei Tikhodeev,** *Moscow State University, Russia*

We report the results of experimental and theoretical study of extinction and photoluminescence spectra of samples with silicon nanocrystals in the proximity of two types of plasmonic modes supported by gold grating. We show how the sub-surface silicon nanocrystals couple to the plasmonic modes and which enhancement factor they have in both cases. Our calculations of transmission and photoluminescent spectra are in agreement with experimental results.

65 - Analytical Model for Rotational and Anisotropic Metasolids

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- **Navid Nemati,** *Laboratoire Modélisation et Simulation Multi Echelle, Université Paris-Est, France*
- **Camille Perrot,** *Laboratoire Modélisation et Simulation Multi Echelle, Université Paris-Est, France*

We present an analytical approach to model a metasolid accounting for anisotropic effects and rotational mode. The metasolid is made of hard inclusions, either cylindrical or spherical, embedded in a stiff matrix via soft claddings. We show that the material exhibit negative mass densities near the translational-mode resonances, and negative density of moment of inertia near the rotational resonances. Based on derived analytical expressions, we demonstrate that the resonances associated with additional modes we take into account, that is, axial translation for cylinders, and rotations for both cylindrical and spherical systems, can occur at lower frequencies compared to the previously studied plane-translational modes.

66 - A Thin Ultra-wideband Microwave Absorbing Structure Printed On Flexible substrate With Resistive-Ink Made Of Multiwall Carbon-Nanotube

- **Rajkumar Jaiswar,** *Universite Catholique de Louvain, Belgium*
- **Francisco Mederos Henry,** *Universite Catholique de Louvain, Belgium*
- **Vedi Dupont,** *Belgian Ceramic Research Centre, Belgium*
- **Sophie Hermans,** *Universite Catholique de Louvain, Belgium*
- **Arnaud Delcorte,** *Universite Catholique de Louvain, Belgium*
- **Christian Bailly,** *Universite Catholique de Louvain, Belgium*
- **Cathy Delmotte,** *Belgian Ceramic Research Centre, Belgium*
- **Véronique Lardot,** *Belgian Ceramic Research Centre, Belgium*
- **Jean-Pierre Raskin,** *Universite Catholique de Louvain, Belgium*
- **Isabelle Huynen,** *Universite Catholique de Louvain, Belgium*

In this paper, we present a ultra-wideband radar absorbing structure operating in 5-50GHz frequency range. Two layer of Frequency Selective Surfaces (FSS) separated by dielectric spacer and having 160 ff/sq. and 80 ff/sq. respectively are printed on flexible PC-sheet with home-made water-based MWCNT-ink. For a thickness of 5mm a measured reflection coefficient bandwidth below -15dB is achieved over a bandwidth of 31GHz between 9-40GHz band, and agrees very well with simulation. The higher absorption bandwidth of absorber at normal incidence is benefitted from the stacked gradient of optimized surface resistance of resistive-FSS structure separated by below o/4 spacer besides the bandwidth of the proposed absorber combines flexibility and compactness.

67 - Critical Dimension Metrology of Plasmonic Photonic Crystals based on Angle-resolved Spectroscopic Mueller Ellipsometry and the Reduced Rayleigh Equation

- **Jean-Philippe Banon,** *Department of Physics, NTNU Norway, Norway*
- **Torstein Nesse,** *Department of Physics, NTNU Norway, Norway*
- **Thomas Brakstad,** *Department of Physics, NTNU Norway, Norway*
- **Per Magnus Walmsness,** *Department of Physics, NTNU Norway, Norway*
- **Morten Kildemo,** *Department of Physics, NTNU Norway, Norway*
- **Ingve Simonsen,** *Department of Physics, NTNU Norway, Norway*

The morphological parameters of rectangular grids of plasmonic nanoparticles of isotropic and anisotropic shapes have been retrieved combining Mueller matrix Ellipsometry and the Reduced Rayleigh Equations. We have recently demonstrated that the RREs are computationally efficient both in terms of memory usage and CPU time. Spectroscopic MME with variable angle of incidence and full azimuthal rotation of the sample is a powerful optical technique to characterize both anisotropic and bi-anisotropic materials, and seems to be well suited to the characterization of metasurfaces. All surfaces in this work were manufactured using Focused Ion Beam Milling.

68 - Ultrahigh-Q Surface Plasmon Polariton Modes in Magnetic Multilayered Structures with Garnet for Sensing Applications

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- **Pavel Kapralov,** *Russian Quantum Center, Russia*
- **Grigory Knyazev,** *Lomonosov Moscow State University, Russia*
- **Sergei Sekatskii,** *École Polytechnique Fédérale de Lausanne, Switzerland*
- **Mohammad Nur-E-Alam,** *Edith Cowan University, Australia*
- **Mikhail Vasiliev,** *Edith Cowan University, Australia*
- **Kamal Alameh,** *Edith Cowan University, Australia*
- **Vladimir Belotelov,** *Lomonosov Moscow State University, Russia*

We design multilayered magnetic structures supporting ultrahigh quality factor surface plasmon polariton modes which are promising for sensing applications. We investigate the impact of the ferromagnetic layer width on the mode propagation length and experimentally observe the long-range propagating magnetoplasmons. The magnetoplasmon propagation length is estimated up to 200 um and resonance quality factor up to 1500.

69 - Extraordinary Light Transmission Through 0-, 1-, 2- Dimensional Lattice Of Nanoholes In The Metal Film

- **Ilya Treshin,** *Dukhov Research Institute of Automatics (VNIIA), Russia*
- **Vasily Klimov,** *Dukhov Research Institute of Automatics (VNIIA), Russia*

We numerically investigated the influence of the spatial dimension of the nanoholes lattice in the metal film which is deposited on the photonic crystal on the extraordinary light transmission through it. The self-focusing effect of light near the single hole is found.

70 - A Compact Broadband Metasurface Based Directive Slot Antenna for Gain Enhancement in C-band

- **Sudhakar Sahu,** *KIIT University, India*
- **Bajra Panjar Mishra,** *KIIT University, India*

Abstract – In this communication, a single sided rectangular split ring resonator (RSRR) based metasurface combined with an edge fed slot antenna is proposed to achieve high dielectric constant (epsilon very large-EVL) and high gain in a broadband of 4-8 GHz. This single layer metasurface is proposed to design low loss, broadband, high efficient compact lens antenna. The design shows an enhancement in gain of 6 dB for the lens feed slot in the frequency range 4.6-7.4 GHz. The permittivity ( ), permeability (Q) and refractive index ( ) variation for the proposed design are nearly zero in the frequency range of 4.2-7.8 GHz. The high dielectric property of the permittivity of the metasurface lens facilitates to design compact broadband lens antenna system. The structure has been designed, simulated and optimized using Finite Element Method based High Frequency Structure Simulator(HFSS).This broadband high gain lens antenna is suitable for C-band communication.

71 - Investigation on Metamaterial Based W-band Lens Antenna Design for Fusion Plasma Diagnostics

- **Sudhakar Sahu,** *KIIT University, India*
- **Bajra Panjar Mishra,** *KIIT University, India*

In this communication, a hybrid metallic strip split ring resonator (SRR) based periodic metamaterial structure is reported for design of W-band lens antenna for absorption and detection of electromagnetic radiation from the plasma. By detecting the intensity of electromagnetic radiation reveal local information in the electron temperature of the emitting radiation. The metamaterial lens has been designed to operate in W-band (70-110 GHz). The unit cell of periodic metamaterial structure is chosen in such a way that, it offers low loss and dispersion, wide band and high gain of the lens structure. The metamaterial structure as lens has been designed, simulated and optimized by commercially available ANSYS HFSS Software. Here we propose a composite metamaterial (CMM) as unit cell structure to realize near zero refractive index to design low loss broadband high gain near zero refractive index metamaterial (NZMTM) lens antenna to increase the focusing effect. Metamaterial lens aperture size is of 1100Qm x 550Qm x 250Qm.

72 - Probing the dynamics of microwave pulses in 1D disordered waveguides

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- **Azriel Genack,** *Queens College of the City University of New-York, United States of America*
- **Patrick Sebbah,** *Bar-Ilan University, Israel*

We report simulations of the time evolution of microwave pulses inside an open 1D random waveguide made of alternating dielectric slabs A or B. Randomness is either introduced by randomly juxtaposing slabs A or B in between the alternating slabs or by introducing a random thickness on each layer. Simulations are performed on particular random configuration or on a high number of configurations. Microwave pulses play the role of a probe and allow the study of the dynamics of localized modes and extended modes in random waveguides in terms of dwell time of the energy in the sample. This work highlights the diversity of dynamical phenomena arising in single realizations of random configuration when those phenomena are hidden by large ensemble averages.

73 - Gap-plasmon optics for the design of optical patch antennas metasurfaces

- **Antoine Moreau,** *Université Clermont Auvergne, France*
- **Caroline Lemaître,** *Université Clermont Auvergne, France*
- **Kofi Edee,** *Université Clermont Auvergne, France*
- **Emmanuel Centeno,** *Université Clermont Auvergne, France*

We propose a unified physics of gap-plasmon resonators, by considering the way gap-plasmons can be excited and reflected in structures similar to patch antennas. This gap-plasmon optics allows to explain many of the features of gap-plasmon resonators, from their extraordinary efficiency at concentrating light to the way they scatter it - or not.

74 - Towards a new frontier of Computational Plasmonics: the Density Functional Tight Binding (DFTB) Method

- **Stefania D'Agostino,** *Center for Biomolecular Nanotechnologies of IIT@UniLe, Lecce, Italy, Italy*
- **Fabio Della Sala,** *Institute for Microelectronics and Microsystems (IMM-CNR), Campus Ecotekne, 73100 Lecce, Italy., Italy*

Electrodynamics methods have been proved to be useful and powerful tools to theoretically study localized and delocalized surface plasmons. Anyway the recent progresses achieved in fabrication techniques to control sub-nanomater structures and features has lead to search for more rigorous approaches able to theoretically describe nonlocality or the spill-out of conduction electrons, effects well visible in very narrow junctions or sub-nanometers gaps. The main shortcoming of the classical approaches consists, in fact, in losing the intrinsic atomistic structure of matter and in neglecting the quantum mechanical effects. Standard atomistic ab-initio time dependent density functional theory (TDDFT) seems to be the most suitable approach for a complete quantum mechanical treatment of plasmons but it becomes computationally unaffordable for particles sizes of several hundreds of atoms. Here we alternatively propone the time dependent Density Functional Tight-Binding Method (TDDFTB) as an efficient and reliable method to describe the optical properties of metallic clusters, molecules and their relative interactions at the atomistic level. We present a new empirical strategy to improve the TDDFTB performances and overcome its limits in reproducing ab-initio TDDFT spectra for tetrahedral closed-shell Agn clusters and report on our best results for handtuned on-site energies. With the proposed parametrization TDDFTB gives results comparable to the reference ones but within a computational time less than 0.1%.

75 - Broad acoustic bandgap switching in structured plates

- **Younes Achaoui,** *Institut FEMTO-ST, Univ. Bourgogne Franche-Comté, France*

We report in this paper a broadband gap switching by harnessing resonance coupling between two perforated plates. We first recall and explain the mechanism of bandgap enlargement, which emanates from destructive interferences in one slotted plate. The trade-off between bandwidth and the shielding efficiency is highlighted. A particular attention is brought to the designed structured plates placed in cascade for broad bandgaps tunability purposes.

76 - Sensors based on 2D waveguide with metallic coating

- **Alexander V. Dorofeenko,** *Dukhov Research Institute of Automatics, Russia*
- **Igor A. Nechepurenko,** *Dukhov Research Institute of Automatics, Russia*
- **Alexander A. Zyablovsky,** *Dukhov Research Institute of Automatics, Russia*
- **Eugeny S. Andrianov,** *Dukhov Research Institute of Automatics, Russia*
- **Alexander A. Pukhov,** *Dukhov Research Institute of Automatics, Russia*
- **Alexey P. Vinogradov,** *Dukhov Research Institute of Automatics, Russia*
- **Yurii E. Lozovik,** *Dukhov Research Institute of Automatics, Russia*

We consider an effect of waveguide mode disappearance in the presence of Ag layer. When the layer thickness exceeds a threshold value, the mode becomes leaky. This leads to 3 orders damping of the mode path length at 1 nm increase in the metal thickness. Such giant sensitivity is useful for sensing (e.g. heavy metal salt sensors), efficient electro-optical modulation, etc.

77 - One-Step Nano Transfer Process for Metasurfaces

- **SoonHyoung Hwang,** *Korea Institute of Machinery & Materials, Korea (South)*
- **Sohee Jeon,** *Korea Institute of Machinery & Materials, Korea (South)*
- **Jae Ryoun Youn,** *Seoul National University, Korea (South)*
- **Jun Ho Jeong,** *Korea Institute of Machinery & Materials, Korea (South)*

Recently, a number of significant and important researches have been published regarding plasmonic effect due to its extraordinary optical property. Even with its extraordinary property, commercialization is limited by the high price to fabrication. In this situation, a lot of research groups have been focused on nano patterning process in order to produce nano scale of plasmonic structure with cost effective process. However, it is difficult to achieve required and designed precise nanoscale dimensions for plasmonic behavior. For this reason, currently plasmonic structure has been fabricated by using expensive and time consuming method such as focused ion beam milling. From this point of view, nano transfer process can solve current issues. More importantly, nano transfer process does not require etch step compared with nano imprint lithography process or optical lithography. In this study, we fabricated a reflectance type of plasmonic metasurfaces with various nano scales of hole diameter and period patterns for structural color printing by using one-step nano transfer process.

78 - Observation of Light Confinement Effect on ZnO Nanograting

- **Won Seok Chang,** *Korea Institute of Machinery and Materials, Korea (South)*

The light-confinement phenomena on the semiconducting ZnO nanograting structure were directly observed by means of confocal microscopy-based scanning photocurrent microscopy (SPCM), exhibiting a high spatial resolution distinguishing the 200 nm width of the ZnO nanostructure. Through diverse periods of nanograting, in this case 600, 800 and 1000 nm, and various incident light intensity levels, we confirmed the period dependent confined modes and thus established the ratio of the photocurrent change according to the incident intensity. Our study can provide accurate and comprehensive information regarding light confinement depending on the nanostructured geometry compared to conventional methods.

79 - Coupling radiation to plasmons in graphene using transformation optics

- **Emanuele Galiffi,** *Imperial College London, United Kingdom*
- **Paloma Arroyo Huidobro,** *Imperial College London, United Kingdom*
- **John Brian Pendry,** *Imperial College London, United Kingdom*

The tunable plasmonic response of graphene to THz radiation make this material extremely promising for ultrathin devices with dynamically configurable properties. However, modulations of the Fermi level of graphene, which can be generated by a rapidly varying external gate voltage, demand a non-electrostatic treatment. We show how the full electrodynamic response of a periodically patterned graphene layer can be obtained analytically thanks to transformation optics.

80 - Magnetic Polarizability of Assembled Planar Extremely Subwavelength Mu-negative Metamaterials

- **Kai FANG,** *Tongji University, China*
- **Quan Wang,** *Tongji University, China*
- **Yewen Zhang,** *Tongji University, China*
- **Yunhui Li,** *Tongji University, China*

Wednesday

An planar extremely subwavelength Mu-negative metamaterials is presented at lowfrequencies, composed of periodically arranged lumped components and subwavelength distributed structureswith the combination of double layer rectangular spiral unit structure. The magnetic polarizabilityisinducedby the resonance of the dual-layer metamaterialsexcited by an alternating electromagnetic field.The equivalentvalueof the magnetic polarizabilityin the metamaterials is obtainedwithan integral treatment of the magnetic polarizability distribution.

81 - Lasing Thresholds in DFB Systems Based on Perforated Metallic Films

• **Ilya Zabkov,** *VNIIA, Russia*

Lasing thresholds in systems based on perforated metallic films were calculated numerically. Influence of different parameters (lattice type, radius and period of holes, height of active layer) on threshold was studied. The existence of optimal value of radius of the holes (around 100 nm) is shown for hexagonal and square lattices.

82 - Time reflection and time refraction of graphene plasmons

• **Galaad Altares Menendez,** *University of Mons, Belgium*
• **Bjorn Maes,** *University of Mons, Belgium*

Changing materials in time gives rise to a special type of reflection and refraction. Here we show that graphene plasmons propagating along a graphene sheet and crossing a temporal boundary experience reflection and transmission, resembling Fresnel reflection and transmission taking place at a spatial boundary. The temporal discontinuity we use is a change of Fermi level in the graphene sheet. The shape of the discontinuity can be tailored to filter specific frequencies. This phenomenon is fairly general and can be extended to other guided resonances.

17:30 - 18:30 — ORAL SESSIONS (WEDNESDAY - AFTERNOON 2)

17:30	THEORY AND MODELLING III Session chairperson: Stefano Maci	SCATTERING ENGINEERING Session chairperson: Oscar Quevedo-Teruel

17:30 - 17:45

THEORY AND MODELLING III: Extracting Polarizability of Complementary Metamaterial Elements Using Love's Theorem

• **Laura Pulido Mancera,** *Duke University, United States*
• **Mohammadreza F. Imani,** *Duke University, United States*
• **Patrick Bowen,** *Duke University, United States*
• **David Smith,** *Duke University, United States*

The Discrete Dipole Approximation (DDA) is a powerful tool used to model and design metasurface antennas for numerous applications such as beamforming arrays, holograms, and flat lenses among others. In this technique, a metasurface is described as a collection of dipoles (meta-atoms) characterized by their polarizability. The utility of this technique relies on polarizability extraction. In this presentation, we employ Loves Theorem to develop a comprehensive procedure for retrieving the polarizability of complementary metamaterial elements, when these are embedded in different structures such as: rectangular waveguide, planar waveguide, and periodic metascreen. We demonstrate that the extracted polarizability changes depending on the surrounding settings, highlighting the importance of proper characterization of meta-atoms in different environments.

SCATTERING ENGINEERING: Mapping Directivity of Coupled Dimers of Meta-Atoms

• **Andrea Vallecchi,** *University of Oxford, United Kingdom*
• **Lianbo Li,** *University of Oxford, United Kingdom*
• **Chris Stevens,** *University of Oxford, United Kingdom*
• **Ekaterina Shamonina,** *University of Oxford, United Kingdom*

Arrays of coupled split ring resonators (SRRs) capable of carrying slow short-wavelength magneto-inductive waves have been shown to support the rapidly varying current distributions required for superdirectivity. However, the superposition of both electric and magnetic dipole resonance modes contributing to radiation of SRRs challenge pure physical intuition in the selection of the optimal dimer configuration reaching the maximum theoretical value of superdirectivity. In this paper a comprehensive analytical model for characterizing the radiation of dimers of coupled meta-atoms with only one element being driven is presented. The model leverage an equivalent circuit description of the coupled resonators in combination with standard radiation formulas. Based on this model, maps of directivity are produced for any orientations of two co-planar split rings resonant at about 2 GHz, leading to identifying the conditions for superdirectivity in terms of orientation and possibly size of the meta-atoms.

83 - Near field evidences of giant optical fields sustained by optimized multi-dielectric stacks

• **Aude Lereu,** *Institut Fresnel, France*
• **Myriam Zerrad,** *Institut Fresnel, France*
• **Julien Lumeau,** *Institut Fresnel, France*
• **Thomas Begou,** *Institut Fresnel, France*
• **Fabien Lemarchand,** *Institut Fresnel, France*
• **Claude Amra,** *Institut Fresnel, France*

Multidielectric coatings have been designed to reach total absorption & maximum field enhancement at resonances that is when working under total internal reflection. We present here the evidences of field enhancement using photon scanning tunneling microscopy.

84 - Regularized Transformation Optics For Transient Heat Transfer

• **Richard Craster,** *Imperial College London, UK*
• **Sebastien Guenneau,** *Institut Fresnel, France*
• **Harsha Hutridurga,** *Imperial College London, UK*
• **Greg Pavliotis,** *Imperial College London, UK*

We report on certain cloaking strategies for transient heat transfer. Regularized Kohn's transform is employed to design cylindrical cloaks and to prove a near-cloak result. Our main result says that, after the lapse of a certain threshold time, the temperature field outside the cylindrical cloak is close to that of the uniformly conducting medium irrespective of the conductivity enclosed in the cloaked region.

17:30 - 18:30 — ORAL SESSIONS (WEDNESDAY - AFTERNOON 2)

17:30	DEVICE APPLICATIONS I Session chairperson: Tiago Morgado	TERAHERTZ WAVES Session chairperson: Maxim Gorkunov

17:30 - 17:45

DEVICE APPLICATIONS I: Meta- Fresnel elements functioned by pixelated one dimensional gratings with space-variant frequencies and orientations

• **Yan Ye, Soochow University,** *China*

By imparting local, space-variant phase changes on an incident electromagnetic wave, metasurfaces are capable of manipulating lights. These surfaces have been constructed from nanometallic optical antennas as well as high-index dielectric antennas. We demonstrate the experimental realization of a flexible Fresnel element, where pixelated one dimensional gratings with space-variant frequencies and orientations are assembled in low-index material, achieving good concentration performance in the visible spectrum.

TERAHERTZ WAVES: Manipulating Terahertz Waves with Metamaterials and Metasurfaces

Invited oral :

• **Miguel Beruete,** *Universidad Pública de Navarra, Spain*

Metamaterials and plasmonics are two of the driving forces that are pushing towards the development of functional THz devices. In particular, metasurfaces and bulk metamaterials are giving a strong impulse, both in basic science and applied research. In this talk I will summarize the latest advancements related with terahertz (THz) technology achieved in the Antennas Group – Teralab at the Public University of Navarre. I will cover several hot topics: first, I will present a cross-dipole metasurface designed for thin-film sensing operating at 0.8 THz; then, I will show an ultra-thin invisibility cloak metasurface based on double coaxial ring elements; finally, I will discuss bulk metamaterials with epsilon near zero (ENZ) characteristic operating at THz. All these devices are numerically analyzed and experimentally demonstrated, with good agreement

17:45-18:00	**The Surface Admittance Equivalence Principle For Cloaking Probleme** • Giuseppe Labate, *Politecnico di Torino, Italy* • Andrea Alù, *University of Texas at Austin, USA* • Ladislau Matekovits, *Politecnico di Torino, Italy* In this paper, we apply a reformulated version of the Surface Equivalence Principle, originally defined for radiating phenomena in terms of tangential fields, to cloaking problems in terms of admittance functions at an arbitrary boundary. In order to cloak a dielectric/metallic object, the tangential fields ratio (admittance) can be controlled at any arbitrary attached/detached surface boundary. The dispersive surface admittance cloak, as originally introduced for Mantle Cloaking, is computed in a closed-form solution at any frequency regime (quasi-static and beyond).	**Multiple Scattering Enabled Superdirectivity From A Subwavelength Ensemble Of Resonators** • Samuel Metais, *Institut Langevin, France* • Fabrice Lemoult, *Institut Langevin, France* • Geoffroy Lerosey, *Institut Langevin, France* Ensembles of resonators arranged on a subwavelength scale, namely, metamaterials, are usually considered for their homogenized properties. It was shown recently that the physics underlying many locally resonant metamaterials can be understood in terms of Fano interferences and multiple scattering. Here we harness multiple scattering in a finite size array of subwavelength resonators of optimized size to achieve superdirectivity.
18:00 - 18:15	**Rapid simulation of lossy resonators via a robust spatial map of Green's tensor** • Parry Chen, *Tel Aviv University, Israel* • David Bergman, *Tel Aviv University, Israel* • Yonatan Sivan, *Ben Gurion University, Israel* We obtain the spatial variation of Green's tensor of lossy resonators in both source and detector positions and orientations without repeated simulation. We construct a simple yet rigorous eigenmode expansion of Green's tensor, bypassing all implementation and interpretation issues associated with the alternative quasinormal eigenmode methods. Modes are defined by a linear eigenvalue problem with permittivity rather than frequency as the eigenvalue. Our simple general implemention using default in-built tools on COMSOL enables simulation of arbitrarily-shaped structures, such as bow-tie antennas. Few eigenmodes are necessary for nanostructures, facilitating both analytic calculations and unified insight into phenomena such as Purcell enhancement, radiative heat transfer, and van der Waals forces.	**Superdirectivity for Coupled Dimers of Meta-Atoms at MHz** • Pavel Petrov, *M.V.Lomonosov Moscow State University, Faculty of Physics, Magnetism Department, Russia* • Anna Radkovskaya, *M.V.Lomonosov Moscow State University, Faculty of Physics, Magnetism Department, Russia* • Christopher Stevens, *University of Oxford, Department of Engineering Science, UK* • Ekaterina Shamonina, *University of Oxford, Department of Engineering Science, UK* It was recently shown that arrays of coupled meta-atoms, capable of carrying slow short-wavelength magneto-inductive waves, are promising candidates for realizing rapidly varying current distributions required for superdirectivity. Superdirective end-fire radiation was confirmed for metamaterial dimers in the GHz range. In this paper we present a theoretical study of metamaterial dimers in the MHz range. We show that the conditions of superdirectivity differ significantly from the case of the GHz elements. We identify superdirective configurations of dimers of meta-atoms of various shape, resonant characteristics and separation. This study paves the way for further work on superdirective metamaterial metasurfaces.
18:15 - 18:30	**Green's Functions, Including Scatterers, for Photonic Crystals and Metamaterials with Applications to Wideband Wave Interactions with Finite Periodic Structures** • Shurun Tan, *University of Michigan, United States* • Leung Tsang, *University of Michigan, United States* The Green's functions are physical responses due to a single point source in a periodic lattice. The point source can also correspond to an impurity or a defect. In this paper, the Green's functions, including the	**Ultra-Thin Electromagnetic Cloak for Hiding a Metallic Obstacle from Antenna Radiation at Low Frequency** • Tatiana Teperik, *C2N - University of Paris Sud, France* • André de Lustrac, *C2N - University of Paris Sud, France* • Guy Sabanowski, *Airbus Group Innovation, France* • Gilles Fournier, *Airbus Group Innovation, france* • Gérard-Pascal Piau, *Airbus Group Innovation, France*

17:45-18:00	**A Monte Carlo Approach For Investigating The Fabrications Imperfections For Lenses** • LiYi Hsu, *UCSD, United States* • Matthieu Dupre, *UCSD, United States* • Abdoulaye Ndao, *UCSD, USA* • Boubacar Kante, *UCSD, United States* In this paper, we introduce and evaluate, for metasurfaces, parameters such as the intercept factor and the slope error usually defined for solar concentrators in the realm of ray-optics. After proposing definitions valid in physical optics, we put forward an approach to calculate them. As examples, we design three different lenses based on three specific unit cells and assess them numerically. The concept allows for the comparison of the efficiency of the metasurfaces, their sensitivities to fabrication imperfections and will be critical for practical systems.	
18:00 - 18:15	**Performance Enhancement of Binary Fresnel Lenses Using Metamaterials** • Santiago Legaria, *Universidad Pública de Navarra, Spain* • Victor Pacheco-Peña, *Universidad Pública de Navarra, Spain* • Miguel Beruete, *Universidad Pública de Navarra, Spain* The aim of this work is to design Binary square Fresnel zone plate lenses (BSFZPL) applying metamaterial concepts in order to improve the performance of this type of lenses typically made with dielectrics or alternating opaque and transparent materials. First we discuss the design parameters using metamaterials. Then we engineer, study and compare different designs: (i) a BSFZPL made with a metamaterial and a dielectric as the two components of the different zones; (ii) a BSFZPL made with two different metamaterials. The designs are performed at 100 GHz and the focusing performance of the lenses are studied and compared.	**1D Chirality In All-Photodesigned THz Metamaterials** • Carlo Rizza, *CNR_SPIN, Italy* • Lorenzo Columbo, *3Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, Italy* • Massimo Brambilla, *Dipartimento Interateneo di Fisica, Università degli Studi e Politecnico di Bari, Italy* • Franco Prati, *2Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell'Insubria, Italy* • Alessandro Ciattoni, *CNR-SPIN, Italy* We suggest that all-photodesigned metamaterials, sub-wavelength custom patterns of photoexcited carriers on a semiconductor, can display an exotic extrinsic electromagnetic chirality in terahertz (THz) frequency range.
18:15 - 18:30	**Reflective Photonic Limiter for the W-band** • Rodion Kononchuk, *University of Texas at San Antonio, USA* • Andrey Chabanov, *University of Texas at San Antonio, USA* • Roney Thomas, *Wesleyan University, USA* • Tsampikos Kottos, *Wesleyan University, USA* • Martin Hilario, *Air Force Research Laboratory, USA* • Benmaan Jawdat, *Air Force Research Laboratory, USA*	**Terahertz Systems Comprising Rolled-up Metal Microhelices and GaAs Slabs** • Elena Naumova, *Rzhanov Institute of Semiconductor Physics, Siberian Branch of Russian Academy of Sciences, Russia* • Victor Prinz, *Rzhanov Institute of Semiconductor Physics, Siberian Branch of Russian Academy of Sciences, Russia* • Sergey Golod, *Rzhanov Institute of Semiconductor Physics, Siberian Branch of Russian Academy of Sciences, Russia*

scatterers, for periodic structures such as photonic crystals and metamaterials are calculated. The Green's functions are in terms of the multiband solutions of the periodic structures. The Green's functions are broadband solutions so that the frequency or wavelength dependences of the physical responses can be calculated readily. It is obtained by integrating the periodic Green's function including the scatterers in the Brillouin zone. Low wavenumber extraction methods are used to accelerate the convergence rate of the multiband expansions. The low wavenumber component represents reactive near field. The multi-band solutions of the periodic structure are first obtained from a surface integral equation solution, which is converted to a linear eigenvalue problem, giving multiple band solutions simultaneously. The Green's function including the scatterers is further used to formulate dual surface integral equations to study wave interactions with finite arrays of periodic scatterers. The Green's function of the periodic scatterers satisfies the boundary conditions on all the scatterers. Thus, the unknowns are only limited to the boundaries enclosing the finite periodic array. This greatly improves the computing efficiency. This approach of solving problems of finite periodic structures is distinct from the effective medium theory where the periodic structure is replaced by a homogeneous material of the effective permittivity and permeability. The effective medium theory is only valid at the long wave limit, while this new approach provides exact solution at all wavenumbers. The application of this Green's function is demonstrated by calculating the reflections from a half-space of periodic scatterers.

We demonstrate numerically and experimentally the feasibility of an ultra-thin invisibility cloak for low frequency antenna applications. We consider a monopole antenna mounted on a ground plane and a metallic obstacle located in its near-field. To restore the radiation patterns of the antenna perturbed by an obstacle we propose here an electromagnetic cloak that consists simply of metallic patches separated from the obstacle by a dielectric substrate. We show that the radiation patterns of the monopole antenna can be restored completely owing resonant electromagnetic modes localized under the patch.

18:30 - 19:30	**BREAK**
19:30 - 23:30	**GALA DINNER : FORT GANTEAUME**

- **Brad Hoff,** *Air Force Research Laboratory, USA*
- **Vlarimir Vasilyev,** *Air Force Research Laboratory, USA*
- **Nicholaos Limberopoulos,** *Air Force Research Laboratory, USA*
- **Ilya Vitebskiy,** *Air Force Research Laboratory, USA*

We design a reflective photonic limiter for the W-band. The design is based on a resonance cavity filled with the Mott insulator, VO2. At low intensity, the layered structure displays strong resonant transmission via the localized cavity mode. As the pulse intensity increases, the heat-induced transition from insulating to metallic phase in VO2 occurs, suppressing the cavity mode and the resonant transmission; the entire multilayer turns highly reflective within the entire photonic band gap.

- **Vladimir Seleznev,** *Rzhanov Institute of Semiconductor Physics, Siberian Branch of Russian Academy of Sciences, Russia*
- **Vitaliy Kubarev,** *Budker Institute of Nuclear Physics, Russian Academy of Science, Siberian Branch, Russia*

The systems comprising arrays of microhelical resonators, GaAs slabs and air spacers were formed with use of the rolling-up and 3D printing technologies and studied. The systems demonstrate the interplay of the half-wave resonance of helices, waveguide and Fabry-Perot resonances, which result in ultrasharp high regular peaks in polarization spectra. The background mechanisms of the peaks are discussed.

18:30 - 19:30	**BREAK**
19:30 - 23:30	**GALA DINNER : FORT GANTEAUME**

Metamaterials 2017
Program

Thursday, 31st August

09:00 - 10:00	PLENARY SESSION IV	
09:00	PLENARY SESSION IV Session chairperson : Mario Silveirinha	
09:00 - 10:00	Simulations Aren't Just Experiments: Analytical Transformations in Photonics Computation • **Steven Johnson,** *Massachusetts Institute of Technology, USA*	
10:00 - 10:30	COFFEE BREAK (THURSDAY MORNING)	
10:30 - 12:30	ORAL SESSIONS (THURSDAY MORNING)	
10:30	SPECIAL SESSION ON HOMOGENIZATION **Organizers :** Sebastien Guenneau; Boris Gralak; Jean-Philippe Groby ; Vicente Romero Garcia **Session chairpersons :** Sebastien Guenneau; Boris Gralak	SPECIAL SESSION ON SEISMIC METAMATERIALS **Organizer:** Stéphane Brûlé **Session chairpersons:** Stéphane Brûlé; Alexander Movchan
10:30 - 10:45	Homogenization of an array of resonators of the Helmholtz Invited oral : • **Agnes Maurel,** *Institut Langevin/ CNRS, France* • **Jean-Jacques Marigo,** *LMS/Ecole Polytechnique, France* • **Jean-François Mercier,** *Poems/ENSTA, France* We present a homogenization method based on two scale matched asymptotic expansion techniques for arrays of Helmholtz resonators. In the resulting effective model, the array is replaced by a homogeneous and anisotropic medium accounting for the cavities of the resonators while jump conditions apply across a fictitious interface accounting for the necks of the resonators. We show that the model is able to describe accurately resonators open with	Efficient filtering of seismic waves with seismic metamaterial composed by sub-wavelength local resonator • **Giovanni Finocchio,** *University of Messina, Italy* • **Orazio Casablanca,** *University of Messina, Italy* • **Giulio Ventura,** *Polytechnic of Turin, Italy* • **Francesca Garescì,** *University of Messina, Italy* • **Bruno Azzerboni,** *University of Messina, Italy* • **Massimo Chiappini,** *Istituto Nazionale di Geofisica e Vulcanologia, Italy* Seismic Metamaterials (SM) can be used to filter secondary earthquake waves showing filtering performance better than traditional seismic insulators and passive energy dissipation systems. To design of SMs which filter the low frequency waves of an earthquake is necessary to solutions with sub-wavelength local

Metamaterials 2017
Program

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10:00 - 10:30	COFFEE BREAK (THURSDAY MORNING)	
10:30 - 12:30	ORAL SESSIONS (THURSDAY MORNING)	
10:30	SPECIAL SESSION ON ACOUSTIC METAMATERIALS FOR NOISE REDUCTION **Organizers:** Vicente Romero Garcia; Jean-Philippe Groby **Session chairpersons:** Vicente Romero Garcia ; Jean-Philippe Groby	QUANTUM AND EXTREME METAMATERIALS **Session chairperson :** Stephen Barnett
10:30 - 10:45	3D-Printed Straw-Inspired Metamaterial For Sound Absorption • **Weichun Huang,** *LAUM, Univ. du Maine, UMR CNRS 6613, France* • **Logan Schwan,** *LAUM, Univ. du Maine, U MR CNRS 6613, France* • **Vicente Romero-Garcia,** *LAUM, Univ. du Maine, UMR CNRS 6613, France* • **Jean-Michel Génevaux,** *LAUM, Univ. du Maine, UMR CNRS 6613, France* • **Jean-Philippe Groby,** *LAUM, Univ. du Maine, UMR CNRS 6613, France* An anisotropic acoustic metamaterial inspired by straw-stacks is reported for sound absorption. Such anisotropic porous medium with inner resonance results in a negative effective compressibility and	Functionality through Extreme Wave Dynamics Invited oral : • **Nader Engheta,** *University of Pennsylvania, USA* In the extreme scenarios of wave-matter interaction, specialized platforms can be exploited to achieve unique functionalities. In this presentation, we will show how we can obtain useful functionalities out of extreme photonic structures. We will present an overview of some of our ongoing work on photonic doping, extreme metasurfaces, informatic metastructures, quantum metamaterials, and symmetry-breaking platforms.

	necks at both extremities (termed two-sided) or open at a single extremity (termed one-sided). In these two cases, the effect of the array spacing is exemplified, which allows (i) to tune the resonance of perfect transmission in the former case and (ii) to realize perfect absorption in the later case.	resonators in order to have compact and cost-efficient solutions. Considering an implementation based on mass-in-mass system, we shows that the use of six order mass-is-mass basis for periodic SMs allows to push the beginning of the band-gap at lower frequencies as compared to fourth order SMs. We also discuss the implication of the non-linear behavior of soil characteristics in the dynamical response of a SM and the implementation of a solution integrating a seismic metamaterial into a regular foundation.
10:45 - 11:00		**Large Scale Elastic Metamaterials for Earthquake Protection** • **Federico Bosia,** *University of Torino, Italy* • **Marco Miniaci,** *University of Le Havre, France* • **Anastasiia Krushynska,** *University of Torino, Italy* • **Nicola Pugno,** *University of Trento, Italy* In this paper, we propose and numerically analyse 3D large-scale elastic metamaterials for the shielding of seismic waves propagating in dissipative soils. We perform a detailed investigation of the influence of geometric and mechanical parameters on the attenuation potential of feasible phononic crystal and locally resonant metamaterial configurations in typical frequency and intensity ranges for seismic waves. Results obtained by Finite-Element eigenfrequency analysis are confirmed by dynamic transient simulations for both surface and guided seismic waves, making this strategy viable for the protection of civil structures against seismic risk.
11:00 - 11:15	**Dynamic Homogenization of Acoustic Metamaterials: Additional Constitutive Parameters** **Invited oral :** • **Daniel Torrent,** *Centre de Recherche Paul Pascal, France* • **Marie-Fraise Ponge,** *Institut de Mécanique et d'Ingénierie, France*	**Seismic Metamaterials for the Disaster Risk Management in Urban Infrastructure** • **Bogdan Ungureanu,** *Institut Fresnel UMR 7249, Aix-Marseille Université, CNRS, Centrale Marseille, 13013 Marseille, France, France* • **Younes Achaoui,** *Institut FEMTO-ST, Université de Franche-Comté, CNRS, 25044 Besançon Cedex, France, France*

	slow sound effects. Impedance tube measurement on a 3-D printed sample provides data in good agreement with the theoretical model.	
10:45 - 11:00	**Metadiffusers: sound diffusers with deep-subwavelength dimensions** • **Noé Jiménez,** *Laboratoire d'Acoustique de l'Université du Maine, UMR CNRS 6613, France* • **Trevor Cox,** *Acoustics Research Centre, University of Salford, United Kingdom* • **Vicent Romero-García,** *Laboratoire d'Acoustique de l'Université du Maine, UMR CNRS 6613, France* • **Jean-Philippe Groby,** *Laboratoire d'Acoustique de l'Université du Maine, UMR CNRS 6613, France* We present deep-subwavelength diffusing surfaces based on acoustic metamaterials, namely metadiffusers. Sound diffusers are surfaces whose acoustic scattering distribution is uniform. Here, we achieve sound diffusion by using acoustic metamaterials composed by rigidly backed slotted panels, each slit being loaded by an array of Helmholtz resonators. Both, strongly dispersive propagation and slow sound speed are observed inside the slits, shifting their quarter wavelength resonances to the deep-subwavelength regime. Thus, the reflection coefficient of each slit can be tailored to obtain either customized reflection phase, moderate or even perfect absorption. By using a set of different slits with tuned geometry we designed surfaces with spatially-dependent reflection coefficients having uniform magnitude Fourier transforms, presenting good diffusion performance. First, various sub-wavelength diffusers based on known number-theoretical sequences such as quadratic residue or primitive root sequences are presented. Second, accurate designs for binary, ternary and index sequence diffusers are presented making use of perfect acoustic absorption. Finally, a 3 cm thick metadiffuser (1/46 times smaller than the wavelength) was designed working efficiently for frequencies ranging from 250 Hz to 2 kHz, i.e., 3 octaves.	
11:00 - 11:15	**Hierarchical Bio-inspired Dissipative Metamaterials For Low Frequency Attenuation** • **Marco Miniaci,** *Laboratoire Ondes et Milieux Complexes - UMR CNRS 6294, France* • **Anastasiia Krushynska,** *University of Torino - Department of Physics, Italy* • **Federico Bosia,** *University of Torino - Department of Physics, Italy*	**Enhanced spontaneous emission and nonlinear frequency conversion at exceptional points of inverse-designed photonic crystals** • **Zin Lin,** *Harvard University, USA* • **Adi Pick,** *Harvard University, USA* • **Weiliang Jin,** *Princeton, USA* • **Alejandro Rodriguez,** *Princeton, USA*

• **Olivier Poncelet,** *Institut de Mécanique et d'Ingénierie, France*

The homogenization of acoustic metamaterials in the dynamic regime takes into account finite values of both frequency and wavenumber, which leads to a set of constitutive parameters non-local in space and time. As a consequence of this dynamic description, additional constitutive parameters emerge, which are required for the proper description of acoustic metamaterials. In this talk we will present two materials where these additional constitutive parameters are important: A Willis material and a weakly dispersive metamaterial. The experimental characterization of these advanced materials will also be discussed.

• **Andre Diatta,** *Institut Fresnel UMR 7249, Aix-Marseille Université, CNRS, Centrale Marseille, 13013 Marseille, France, France*
• **Ronald Aznavourian,** *Institut Fresnel UMR 7249, Aix-Marseille Université, CNRS, Centrale Marseille, 13013 Marseille, France, France*
• **Stéphane Brûlé,** *Dynamic Soil Laboratory, Ménard, 91620 Nozay, France, France*
• **Stefan Enoch,** *Institut Fresnel UMR 7249, Aix-Marseille Université, CNRS, Centrale Marseille, 13013 Marseille, France, France*
• **Sébastien Guenneau,** *Institut Fresnel UMR 7249, Aix-Marseille Université, CNRS, Centrale Marseille, 13013 Marseille, France, France*

A paradigm shift has occurred in the past five years on seismic wave control with large-scale metamaterials with potential applications in seismic protection. This application of metamaterials theory generates novel approaches to reduce the seismic waves effects on urban infrastructure. We select here three designs of seismic metamaterials: 3D inertial resonators, auxetic metamaterials and the concept of Metacity.

11:15 - 11:30

The role of large scale computing behind the development of seismic (and elastic) metamaterials

• **Andrea Colombi,** *Imperial College London, United Kingdom*
• **Philippe Roux,** *ISTerre Grenoble, France*
• **Marco Miniaci,** *Universite' du Havre, France*
• **Richard Craster,** *Imperial College London, United Kingdom*
• **Sebastien Guenneau,** *Institut Fresnel Marseille, France*
• **Philippe Gueguen,** *ISterre Grenoble, France*

The high complexity of the seismic wave propagation in heterogeneous soils with realistic geological structures makes the development of seismic metamaterials a fertile ground for parallel, high-performance computational elastodynamics. In this talk we review some computational intensive studies used to improve the control capacities of metamaterials on seismic waves and to prepare large-scale experiments.

11:30 - 11:45

Nonasymptotic and Nonlocal Homogenization of Electromagnetic Metamaterials: Theories Based on Trefftz Approximations

• **Igor Tsukerman,** *The University of Akron, USA*

The proposed homogenization methodology applies to periodic electromagnetic structures (photonic crystals and metamaterials), treated on two main spatial scales in the frequency domain. Fields on the fine and coarse scales are approximated via Trefftz bases, i.e. by functions satisfying the underlying

An overview of seismic metamaterials

• **Richard Craster,** *Imperial College, United Kingdom*
• **Tryfon Antonakakis,** *Multiwave AG, Switzerland*
• **Younes Achaoui,** *Institute Fresnel, Marseille, France*
• **Daniel Colquitt,** *University of Liverpool, UK*
• **Stefan Enoch,** *Institut Fresnel, France*
• **Sebastien Guenneau,** *Institut Fresnel, France*
• **Philippe Roux,** *ISTerre, Grenoble, France*

This talk will review the progress made on three

• **Bruno Morvan,** *Laboratoire Ondes et Milieux Complexes - UMR CNRS 6294, France*
• **Nicola Pugno,** *University of Trento - Laboratory of Bio-Inspired and Graphene Nanomechanics, Italy*

In this work, we numerically and experimentally investigate the influence of bioinspired hierarchical organization and material viscoelasticity on the wave dispersion diagram in metamaterials with self-similar structures at various spatial scales. The study reveals that the hierarchical architecture combined with viscoelastic material properties provides advantages for the dynamic performance with respect to conventional metamaterials.

We describe and apply a powerful inverse-design method based on topology optimization to design complex photonic crystals supporting Dirac points formed out of the accidental degeneracy of modes used to realize EPs of arbitrary order as well as complex contours of EPs. We bound the possible enhancements and spectral modifications in the spontaneous emission rate of emitters in the vicinity of EPs in both linear and nonlinear media.

11:15 - 11:30

Damping in a Locally Resonant Metamaterial using Inverse and Direct Unit Cell Modelling

• **Lucas Van Belle,** *KU Leuven, Department of Mechanical Engineering, Belgium*
• **Wim Desmet,** *KU Leuven, Department of Mechanical Engineering, Belgium*

This paper discusses the influence of damping on the dispersion curves of a locally resonant metamaterial. Unit cell analysis is applied and solved using both an inverse and a direct approach, leading to respectively complex frequencies and complex propagation constants. The manifestation of damping effects using both unit cell approaches is presented and compared.

First-principles study of the Haldane model in artificial graphene

• **Sylvain Lannebère,** *Instituto de Telecomunicações - Universidade de Coimbra, Portugal*
• **Mário Silveirinha,** *University of Lisbon – Instituto Superior Técnico,, Portugal*

We present a first-principles study of the Haldane model in an ``artificial graphene'' platform formed by a two-dimensional electron gas modulated by an electrostatic potential with the honeycomb symmetry and by a static spatially-varying magnetic field. The relation between the tight-binding parameters and the actual physical parameters is found. The overall topological properties of the material are determined and compared to the Haldane's theory, and the consequences of a quantized Hall conductivity on the photonic topological properties are discussed.

11:30 - 11:45

Bloch Theorem Applied To Structures With Additional Symmetries: Reduced Unit Cell And Irreducible Brillouin Zone

• **Florian Maurin,** *KU Leuven, Belgium*
• **Claus Claeys,** *KU Leuven, Belgium*
• **Lucas Van Belle,** *KU Leuven, Belgium*
• **Elke Deckers,** *KU Leuven, Belgium*
• **Wim Desmet,** *KU Leuven, Belgium*

Bloch theorem provides a useful tool to analyze wave propagation in periodic systems. While this

Topological Casimir force phase transitions in the graphene family

• **Wilton Kort-Kamp,** *Los Alamos National Laboratory, USA*
• **Pablo Rodriguez-Lopez,** *University of South Florida, USA*
• **Lilia Woods,** *University of South Florida, USA*
• **Diego Dalvit,** *Los Alamos National Laboratory, USA*

The expansion of the graphene family by adding silicene, germanene, and stanene opens a promising

	equations and boundary conditions (Bloch modes on the fine scale and generalized plane waves on the coarse scale). From this general setup, one derives a hierarchy of models, with various trade-offs between accuracy and simplicity: (i) static (i.e. asymptotic, cell size tending to zero); this model does not predict nontrivial magnetic effects; (ii) non-asymptotic but local; (iii) nonlocal; (iv) and, finally, full numerical simulations of the whole fine-scale structure of the metamaterial. Numerical examples demonstrate that nonlocal models can improve the accuracy of homogenization by an order of magnitude.	different ways to divert, reflect or guide elastic waves around structures. Although couched in the language of seismic waves the ideas are scalable and pertinent to elastic waves at different scales such as in ultrasonics. The talk will cover mode conversion of surface to bulk waves via a metasurface of subwavelength resonators, the use of gradient index surface lenses and of phononic crystals with zero-frequency band-gaps.
11:45 - 12:00	**Homogenization of Quasiperiodic Maxwell equations with a non-linear conductivity** • **Elena Cherkaev,** *University of Utah, Department of Mathematics, USA* • **Sebastien Guenneau,** *Aix-Marseille Universite, CNRS, Centrale Marseille, Institut Fresnel, France* • **Niklas Wellander,** *Swedish Defence Research Agency, Sweden* We homogenize a time domain formulation of Maxwell's equations with a nonlinear conductivity assumption in a quasiperiodic composite setting.	**A Multi-mass metabarrier to protect buildings from seismic Rayleigh waves** **Antonio Palermo,** *University of Bologna, Italy* • **Matteo Vitali,** *University of Bologna, Italy* • **Alessandro Marzani,** *University of Bologna, Italy* Metabarriers of surface resonant structures can redirect seismic Rayleigh waves into the soil bulk reducing the surface ground motion. Here we investigate multi-mass metabarriers able to open multiple band gaps in the low frequency range [1-20] Hz and target known resonance frequencies of buildings and infrastructures.
12:00 - 12:15	**Clarifying the Origin of Wood's Anomalies and Surface Modes using an Effective Medium Theory Approach** • **Patrick Bowen,** *Duke University, USA* We present a novel approach based on effective medium theory to understanding and analytically predicting Wood's anomalies, surface modes, and scattering spectra in optical, metallic gratings, and we compare this theory with computational results. The approach clearly outlines how the diffuse Wood's anomaly corresponds to a surface mode while the sharp anomaly corresponds to a change in radiation Q due to the addition or subtraction of diffraction orders. As a test geometry, we choose to base our study on a metasurface consisting of a periodic array of film-coupled nanopatch antennas.	**Modelling And Experimental Verification Of A Single Phase Three-Dimensional Lightweight Locally Resonant Elastic Metamaterial With Complete Low Frequency Bandgap** • **Luca D'Alessandro,** *Politecnico di Milano, Italy* • **Edoardo Belloni,** *Politecnico di Milano, Italy* • **Gabriele D'Alò,** *Politecnico di Milano, Italy* • **Luca Daniel,** *Massachusetts Institute of Technology, USA* • **Raffaele Ardito,** *Politecnico di Milano, Italy* • **Alberto Corigliano,** *Politecnico di Milano, Italy* • **Francesco Braghin,** *Politecnico di Milano, Italy* This work presents a three-dimensional, single phase, elastic periodic structure endowed with a complete bandgap at sub-wavelength regime generated by a distributed set of local resonators. The influence of the unit cell parameters on the bandgap width is

	method has been developed for structures periodic by translation, we show that when glide (translation plus reflection) or screw (translation plus rotation) symmetries are present, they can be accounted by revisiting the boundary conditions of the Bloch theorem. By considering a smaller periodicity, the computational cost decreases and the interpretability of the dispersion diagram improves (i.e. the number of folding and non-interacting intersecting curves is reduced). Concerning computational cost reduction, we recall the choice of the irreducible Brillouin zone in terms of the unit cell symmetries, and we show that band-gap characteristics can be obtained from the irreducible Brillouin zone contour, only when bisectors or diagonals of the unit cell are mirror axes. Otherwise, the full irreducible Brillouin zone has to be considered.	platform to probe Dirac-like physics in honeycomb staggered systems in fluctuation induced phenomena. We discover topological Casimir force phase transitions between these staggered 2D materials, induced by the complex interplay between Dirac physics, spin-orbit coupling, and externally applied fields. Furthermore, due to the topological properties of these materials, repulsive and quantized Casimir interactions become possible.
11:45 - 12:00	**Fractal and Spider Web-Inspired Labyrinthine Acoustic Metamaterials** • **Anastasiia Krushynska,** *Department of Physics, University of Turin, Italy* • **Federico Bosia,** *Department of Physics, University of Turin, Italy* • **Marco Miniaci,** *Laboratoire Ondes et Milieux Complexes, University of Le Havre, France* • **Nicola Pugno,** *Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy* This work presents novel approaches for designing labyrinthine acoustic metamaterials with extreme and/or tunable dispersion characteristics. The first approach is inspired by fractal-type plane-filling curves, the use of which allows extending the labyrinthine wave paths to maximum possible lengths. The second approach harnesses the biological structures, e.g. spider-web architecture, to achieve tunability of frequency bands.	**Light-Matter Couplings In Evanescent Fields** • **Ivan Fernandez-Corbaton,** *Kalrsruhe Institute of Technology, Germany* • **Xavier Zambrana-Puyalto,** *Istituto Italiano di Tecnologia, Genova, Italy* • **Nicolas Bonod,** *Aix Marseille Univ, CNRS, Institut Fresnel, Marseille, France* • **Carsten Rockstuhl,** *Kalrsruhe Institute of Technology, Germany* The current miniaturization trends in nanophotonics augment the need for comprehensive models of light-matter couplings in the near field. We have developed a theoretical approach which provides both an intuitive understanding of evanescent light-matter interactions, and the means for making rigorous quantitative predictions. We use our approach to explain recent experimental results. Media link : See publication https://journals.aps.org/pra/abstract/10.1103/PhysRevA.94.053822
12:00 - 12:15	**Slow Sound acoustic diode** • **Yves Aurégan,** *LAUM, CNRS, Le Mans Univ. , France* • **Vassos Achilleos,** *LAUM, CNRS, Le Mans Univ. , France* • **Vincent Pagneux,** *LAUM, CNRS, Le Mans Univ. , France* We demonstrate theoretically and experimentally that an acoustical diode can be achieved in an airflow duct by slowing down the acoustic wave with locally reacting impedance boundary conditions at the walls. In the Slow Sound region, the effective sound velocity can be so low that no wave can propagate against the flow while the propagation is still possible in the flow direction. This phenomenon can occurs on a large frequency range that can be extended to very low frequencies.	**Light interaction and quantum transport in atomic chain chirally coupled to a waveguide** • **Danil F. Kornovan,** *ITMO University, Russia* • **Alexandra S. Sheremet,** *ITMO Unviersity, Russian Quantum Center, Russia* • **Ivan S. Iorsh,** *ITMO University, Russia* • **Mihail I. Petrov,** *ITMO University, Russia* In this work we considered light interaction with two-level quantum systems chirally coupled to a single guided mode with account for a spin-locking effect. The chiral coupling allows achieving asymmetric interaction between the two-level systems, which strongly affects the light scattering of a guided mode of an optical nanofiber by one-dimensional atomic chain. We have also build an analytical model of unidirectional transport of quantum excitation and verified it with modelling of atoms coupled with surface plasmon polariton mode of a metallic

		numerically assessed. Numerical and experimental transmission spectra are presented.
12:15 - 12:30	**Homogenization of metamaterials beyond a local response** • **Karim Mnasri,** *Karlsruhe Institute for Technology, Germany* • **Andrii Khrabustovskyi,** *Karlsruhe Institute for Technology, Germany* • **Christian Stohrer,** *Karlsruhe Institute for Technology, Germany* • **Michael Plum,** *Karlsruhe Institute for Technology, Germany* • **Carsten Rockstuhl,** *Karlsruhe Institute for Technology, Germany* The discussion of the properties of metamaterials on physical grounds and their consideration in applications resides on the assignment of effective material parameters. Usually, weak spatial dispersion (WSD) is considered. The metamaterial is then homogenized by bi-anisotropic material parameters. However, this is often insufficient as the metamaterial is characterized by strong spatial dispersion (SSD). Here, we outline a general approach to homogenize metamaterials by considering SSD, i.e. considering constitutive relations beyond a local response. We study here predominantly the properties of bulk metamaterials by exploring their dispersion relation but also outline at the conference the necessary interface conditions for these advanced constitutive relations.	**Tunable Electrical Bragg band gaps in piezoelectric plates** • **Clément Vasseur,** *IEMN (UMR 8520 CNRS), France* • **Charles Croenne,** *IEMN (UMR 8520 CNRS), France* • **Jerome Vasseur,** *IEMN (UMR 8520 CNRS), France* • **Bertrand Dubus,** *IEMN (UMR 8520 CNRS), France* • **Claude Prevot,** *Thales Research Technology, France* • **Mai Pham Thi,** *Thales Research Technology, France* • **Anne-Christine Hladky-Hennion,** *IEMN (UMR 8520 CNRS), France* A piezoelectric plate poled along its thickness is considered. A periodic grating of electrodes is deposited on its top and bottom surfaces. The device exhibits an electrical Bragg band gap that is open or closed, depending on the electrical boundary conditions applied on the electrodes. Fabrication of the device and first measurements are also presented.
12:30 - 14:00	LUNCH BREAK (THURSDAY)	
14:00 - 15:30	ORAL SESSIONS (THURSDAY - AFTERNOON 1)	
14:00	**EXPERIMENTAL TECHNIQUES, FABRICATION AND CHARACTERIZATION OF METAMATERIALS** Session chairperson: Xiangdong Zhang	**HYPERBOLIC METAMATERIALS** Session chairperson: Evgeniy Narimanov
14:00 - 14:15	**Spatial Dispersion Effects in Magnetic Metamaterials in Visible Light** Invited oral : • **Daniel Torrent,** *CNRS - Centre de Recherche Paul Pascal, France* • **Sergio Gomez-Graña,** *CNRS - ICMCB Bordeaux, France* • **Vasyl Kravets,** *University of Manchester, UK* • **Alexander Grigorenko,** *University of Manchester, UK* • **Alexandre Baron,** *CNRS - Centre de Recherche Paul Pascal, France* • **Virginie Ponsinet,** *CNRS - Centre de Recherche Paul Pascal, France*	**Hyperbolic cavitities as tunable platform for spontaneous emission enhancement of dye molecules** • **Maximilian Goetz,** *Helmholtz-Zentrum Berlin für Materialien und Energie, Germany* • **Robert Kieschke,** *Institut of Physics, AG Theoretical Optics & Photonics, Humboldt-Universität zu Berlin, Germany* • **Julia Werra,** *Institut of Physics, AG Theoretical Optics & Photonics, Humboldt-Universität zu Berlin, Germany*

		nanowire. In particularly, we showed the tolerance of the unidirectionally coupled systems over the positional disorder of the two-level systems.
12:15 - 12:30	**Asymptotic analogies for closely packed photonic and phononic crystals** • **Alice Vanel,** *Imperial College London, United Kingdom* • **Ory Schnitzer,** *Imperial College London, United Kingdom* • **Richard Craster,** *Imperial College London, United Kingdom* Mechanical waves through periodic mass-spring lattices have long acted to gain intuition about waves through continua containing periodic inclusions such as photonic crystals. Our aim here, in the limit of closely arranged inclusions, is to make the analogy quantitative. Techniques based upon matched asymptotic expansions are used to replace the crystal by an effective mass-spring lattice.	**Including non-local absorption in quantum hydrodynamic theory for nano-plasmonic systems** • **Cristian Ciracì,** *Istituto Italiano di Tecnologia, Italy* The quantum hydrodynamic theory is a promising method for describing microscopic details of macroscopic systems. The hydrodynamic equation is directly obtained from a single particle Kohn-Sham equation. This derivation allows to straightforwardly incorporate in the hydrodynamic equation a viscoelastic term, so that broadening of collective excitation can be taken into account, as well as a correction to the plasmon dispersion. The result is an accurate and computationally efficient hydrodynamic description of the free electron gas.
12:30 - 14:00	LUNCH BREAK (THURSDAY)	
14:00 - 15:30	ORAL SESSIONS (THURSDAY - AFTERNOON 1)	
14:00	**LIGHT TRAPPING** Session chairperson: Alejandro Rodriguez	**TIME VARYING METAMATERIALS** Session chairperson: Nader Engheta
14:00 - 14:15	**Light Trapping In Thin-Fim Solar Cells: From Plasmonic To Dielectric Structures** Invited oral : • **Constantin Simovski,** *Aalto University, Finland* During the last decade the idea of light-trapping in thin-film solar cells was compromised by an amount of works which have not resulted in something practical. In this paper we review the basic features of light-trapping structures (LTSs). Since the idea of light trapping due to some resonances and the needed very broad band of this effect contradict one another, we suggest to develop non-resonant all-dielectric LTSs.	**Spatio-Temporal Modulated Doppler Cloak for Antenna Matching at Relativistic Velocity** • **Davide Ramaccia,** *Roma Tre University, Italy* • **Dimitrios L. Sounas,** *University of Texas at Austin, Texas (US)* • **Andrea Alù,** *University of Texas at Austin, Texas (US)* • **Alessandro Toscano,** *Roma Tre University, Italy* • **Filiberto Bilotti,** *Roma Tre University, Italy* In this contribution, we present the concept of Doppler cloak applied to narrowband antennas in order to address the issue of mismatch caused by the Doppler frequency shift. Here, we consider an

	• **Philippe Richetti,** *CNRS - Centre de Recherche Paul Pascal, France* • **Philippe Barois,** *CNRS - Centre de Recherche Paul Pascal, France* We showed in a recent work that the optical properties of self-assembled bulk metamaterials made of "Raspberry-like" plasmonic nanoclusters are well described by a magnetic permeability parameter Q that deviates significantly from 1 in visible light. We question in this paper the validity of the permeability parameter from an experimental point of view. We investigate the effect of spatial dispersion near the plasmon resonance and we quantify the deviation from the classical permittivity-permeability approach.	• **Kurt Busch,** *Institut of Physics, AG Theoretical Optics & Photonics, Humboldt-Universität zu Berlin & Max Born Institute, Germany* • **Katja Hoeflich,** *Helmholtz-Zentrum Berlin für Materialien und Energie, Germany* Hyperbolic cavitites from silver / silicon dioxide multilayers are presented as tunable platforms for spontaneous emission enhancement of embedded dye molecules.
14:15 - 14:30		**Polarization Dependent Electric And Magnetic Purcell Factor In A Microwave Hyperbolic Metamaterial** • **Kaizad Rustomji,** *Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, UMR 7249, 13013 Marseille, France, Australia* • **Redha Abdeddaim,** *Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, UMR 7249, 13013 Marseille, France, France* • **Martijn de Sterke,** *Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS) and Institute of Photonics and Optical Science (IPOS), School of Physics, University of Sydney, NSW 2006, Australia, Australia* • **Boris Kuhlmey,** *Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS) and Institute of Photonics and Optical Science (IPOS), School of Physics, University of Sydney, NSW 2006, Australia, Australia* • **Stefan Enoch,** *Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, UMR 7249, 13013 Marseille, France, France* The electric and magnetic Purcell factor of a hyperbolic metamaterial (HMM) is studied numerically and experimentally from impedance of dipole antennas at microwave frequencies between 5-15-GHz. The Purcell factor is different for transverse magnetic (TM) and transverse electric (TE) polarizations as measured using electric and magnetic dipoles. The antenna impedance method is used to numerically calculate the density of states (DOS) of the metamaterial and is in good agreement with the DOS obtained from band-structure calculations. We show that impedance measurements of dipole antenna can be developed as a versatile tool to study the Purcell factor and DOS at microwave frequencies.
14:30 - 14:45	**Nanoplasmonic Passive and Active Materials for Visible and Near-infrared Wavelengths by Crystal Growth** **Invited oral :** • **Dorota Pawlak,** *Institute of Electronic Materials*	**De-magnifying Hyperlens for Photolithography and Spectroscopy Applications** **Invited oral :** • **Jingbo Sun,** *University at Buffalo, The State University of New York, USA*

		antenna system composed by two antennas which are moving one with respect to the other. Our preliminary results on the observed frequency by the moving receiving antenna demonstrate that, by covering the antenna with the Doppler cloak, the observed Doppler shifted signal is frequency mixed, moving the band of the propagating signal within the operative band of the receiving antenna. For an external observer, therefore, the receiving antenna turns out to be always matched, despite the experienced Doppler frequency shift, and thus its actual velocity.
14:15 - 14:30		**Doppler Effect Based Mixer for Microwave Frequency** • **Jia Ran,** *Tongji University;Queen Mary University of London, China* • **Yewen Zhang,** *Tongji University, China* • **Xiaodong Chen,** *Queen Mary University of London; University of Electronic Science and Technology of China, UK* • **Hong Chen,** *Tongji University, China* We proposed a novel Doppler effect based microwave frequency mixer which mixes the incident wave with its Doppler shifted frequency, instead of a local oscillator. The Doppler shifted frequency originates from an effective moving reflective surface built inside the mixer. This kind of mixer can be low-cost without local oscillators, meanwhile the intermediate frequency is tunable electronically.
14:30 - 14:45	**Nanophotonic Lasers based on Bound States in the Continuum** • **Ashok Kodigala,** *University of California at San Diego, USA*	**Towards Space-Time Metamaterials** **Invited oral :** • **Christophe Caloz,** *Polytechnique Montréal, Canada* Metamaterials may be generally classified in terms of the direct and indirect space and time, or space-time

	Technology, Poland • **P. Osewski,** *Institute of Electronic Materials Technology, Poland* • **M. Kurowska,** *Institute of Electronic Materials Technology, Poland* • **A. Antolik,** *Institute of Electronic Materials Technology, Poland* • **R. Nowaczynski,** *Centre of New Technologies, Poland* • **P. Paszke,** *Centre of New Technologies, Poland* • **M. Gajc,** *Institute of Electronic Materials Technology, Poland* • **K. Sadecka,** *Institute of Electronic Materials Technology, Poland* • **B. Surma,** *Institute of Electronic Materials Technology, Poland* We report on the development of volumetric nanoplasmonic active and passive materials and metamaterials in the Vis and NIR wavelength ranges by the crystal growth methods. This includes eutectic composites where a monolith material structured on the nano/micron scale is made out of two or more component crystalline phases. As well as materials manufactured by the NanoParticle Direct Doping method where a dielectric matrix can be doped with various nanoparticles without a chemical reaction.	• **Tianboyu Xu,** *University at Buffalo, The State University of New York, USA* • **Natalia Litchinitser,** *University at Buffalo, The State University of New York, USA* Recent progress in photonic materials, such as metamaterials, enable unprecedented control over light propagation and open a new paradigm for spin and orbital momenta related phenomena in optical physics. Metamaterials enable light manipulation on subwavelength scale. By exploiting strongly anisotropic optical properties of nanostructures, we experimentally demonstrate optical patterning below the diffraction limit enabled by the de-magnifying hyperlens operating at visible wavelengths. Next, we demonstrate a possibility of generation and subwavelength de-magnification of structured light beams using the de-magnifying hyperlens and its potential applications for spectroscopy applications.
14:45 - 15:00		
15:00 - 15:15	**Self-assembly of Si- and SiGe-based dielectric Mie resonators via templated solid-state dewetting** • **Marco Abbarchi,** *AMU, IM2NP CNRS, France* We provide theoretical and experimental evidence of solid state dewetting of ultra-thin silicon and silicon-germanium films on insulators as an alternative fabrication method and semiconductor material for dielectric Mie resonator applications. These dielectric resonant particles can be obtained over very large surfaces on arbitrary silica substrates.	**Resolution revival technique for subwavelength imaging** • **Andrey Novitsky,** *Technical University of Denmark, Denmark* • **Taavi Repan,** *Technical University of Denmark, Denmark* • **Sergei Zhukovsky,** *Technical University of Denmark, Denmark* • **Andrei Lavrinenko,** *Technical University of Denmark, Denmark* The method to achieve a high resolution of subwavelength features (to improve the contrast function) for a dark-field hyperlens --- hyperbolic metamaterial slab possessing metallic properties at the interface --- is developed. The technique requires the introduction of the phase difference between the objects to be resolved.

	• **Thomas Lepetit,** *University of California at San Diego, USA* • **Qing Gu,** *University of California at San Diego, USA* • **Babak Bahari,** *University of California at San Diego, USA* • **Yeshaiahu Fainman,** *University of California at San Diego, USA* • **Boubacar Kante,** *University of California at San Diego, USA* We have designed a high quality factor cavity that is based on a bound state in the continuum and harnessed its properties to demonstrate a novel type of surface emitting laser. We have experimentally demonstrated lasing action in this compact nanophotonic laser at room temperature with a very low threshold power.	(ST), dependencies of their bianisotropic constitutive parameters. This classification leads to a set of 16 distinct types of metamaterials, among which those having time dependence have hardly been explored to date. This paper represents a step in the systematic investigation of media belonging to the uncharted territory of ST metamaterials, i.e. media with both space and time structure. It first establishes fundamental ST-media concepts and tools, next describes the physics and modeling of ST media made of abrupt and sinusoidal discontinuities, and finally presents a couple of related application examples.
14:45 - 15:00	**Light trapping in an all-dielectric open cavity** • **Solange Vieira da Silva,** *Instituto de Telecomunicações and Department of Electrical Engineering, University of Coimbra,, Portugal* • **Tiago Morgado,** *Instituto de Telecomunicações and Department of Electrical Engineering, University of Coimbra, Portugal* • **Mário Silveirinha,** *Instituto de Telecomunicações and University of Lisbon, Instituto Superior Técnico, Portugal* Here we suggest a new approach to trap light in an all-dielectric open subwavelength cavity. The interplay of a Fano resonance and a nonlinear response enables storing the electromagnetic radiation within the open dielectric cavity for a long period of time. The proposed light trapping mechanism may be an interesting alternative to conventional electrically-large whispering gallery resonators, or to core-shell plasmonic resonators sensitive to ohmic losses.	
15:00 - 15:15	**Dark Modes Engineering In Metasurfaces** • **Elena Bochkova,** *Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, Université Paris-Saclay, France* • **Shah Nawaz Burokur,** *LEME, EA 4416, Université Paris Nanterre, 92410 Ville d'Avray, France, France* • **Andre de Lustrac,** *Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, Université Paris-Saclay;Université Paris Nanterre, 92410 Ville d'Avray, France, France* • **Anatole Lupu,** *Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, Université Paris-Saclay, France* We revisit the engineering of metasurfaces intended to obtain sharp features in their spectral response. We show that in contrast to the conventional approach exploiting Fano type interference between dark and bright resonant elements, a more flexible and efficient engineering of the spectral response can be achieved by using distinctly different mechanisms for the excitation of dark modes.	**Meta-atoms and Metamaterials in Motion** **Invited oral :** • **Pavel Ginzburg,** *Tel Aviv University, Israel* • **Dmitri Filonov,** *Tel Aviv University, Israel* • **Vitali Kozlov,** *Tel Aviv University, Israel* Electromagnetic interactions with moving and accelerating bodies inspires variety of remarkable phenomena. Time-dependent boundary conditions for electromagnetic waves give rise to parametric generation of new frequencies, which analysis could characterize both the mechanical motion and an internal geometric structure of a scatterer. Here, axially rotating subwavelength (cm-range) structures, such as rings, wires, and their combinations are analyzed theoretically, numerically and experimentally. Micro-Doppler spectroscopy and frequency comb generations are demonstrated and attributed to internal structures of considered objects.

15:15 - 15:30	**Solution Processing Of Non-Centrosymmetric Nanomaterials For Photonic Crystal Applications** • **Viola V. Vogler-Neuling,** *ETH Zurich, Switzerland* • **Nicholas R. Hendricks,** *ETH Zurich, Switzerland* • **Barbara Schneider,** *ETH Zurich, Switzerland* • **Victor Chausse,** *ETH Zurich, Switzerland* • **Rachel Grange,** *ETH Zurich, Switzerland* We present an economical solution processing method to fabricate nonlinear photonic crystals with barium titanate nanomaterials. Three-dimensional woodpile structures were realized by combining nanoimprint lithography with colloidal suspensions of nonlinear materials and inverse opal structures composed of nonlinear nanoparticles were fabricated for the infrared wavelength range by evaporation induced self-assembly.	**Experimental demonstration of a magnifying prism hyperlens at THz frequencies** • **Md. Samiul Habib,** *The University of Sydney, Australia* • **Alessio Stefani,** *The University of Sydney, Australia* • **Shaghik Atakaramians,** *The University of Sydney, Australia* • **Simon Fleming,** *The University of Sydney, Australia* • **Alexander Argyros,** *The University of Sydney, Australia* • **Boris Kuhlmey,** *The University of Sydney, Australia* We experimentally demonstrate a magnifying wire medium (WM) prism hyperlens at THz frequencies. The different lengths of wire in the prism have different resonance frequencies, so that there is no frequency at which a good image is possible. We show that using spatially varying time gating or frequency convolution the resonant response can be removed and experimentally demonstrate sub-diffraction magnified imaging of a sub-wavelength double aperture.
15:30 - 16:00	**COFFEE BREAK (THURSDAY AFTERNOON)**	
16:00 - 17:30	**ORAL SESSIONS (THURSDAY - AFTERNOON 2)**	
16:00	**ABSORBERS** Session chairperson: Davide Ramaccia	**DEVICE APPLICATIONS II** Session chairperson: Miguel Beruete
16:00 - 16:15	**Universal metamaterial absorber** • **Fatima Omeis,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France* • **Rafik Smaali,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France* • **Antoine Moreau,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France* • **Thierry Taliercio,** *Université Montpellier,CNRS, IES, UMR 5214, F-34000, Montpellier, France, France* • **Emmanuel Centeno,** *Universite Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France* We propose a universal design which provides simple scaling laws that can be used as a recipe to realize ultra-thin perfect absorbers operating from infrared to microwave frequencies independently of the choice of the materials (i.e metal and dielectric) involved and for all polarization states of light.	**Chipless RFID Tags Based On Metamaterial Concepts** **Invited oral :** • **Cristian Herrojo,** *Universitat Autònoma de Barcelona, Spain* • **Javier Mata-Contreras,** *Universitat Autònoma d e Barcelona, Spain* • **Ferran Paredes,** *Universitat Autònoma de Barcelona, Spain* • **Ferran Martín,** *Universitat Autònoma de Barcelona, Spain* Tags for chipless RFID based on S-SRR resonators are presented in this paper. Tag reading is carried out by means of near-field coupling, by displacing the S-SRRs above a CPW. Through this sequential bit reading, the number of bits is only limited by the area occupied by the tag.

15:15 - 15:30	**Metal-dielectric nanocavity as a versatile optical sensing platform** • **Dmitry Zuev,** *ITMO University, Russia* • **Valentine Milichko,** *ITMO University, Russia* • **Denis Baranov,** *Chalmers University of Technology, Moscow Institute of Physics and Technology, Russia* • **George Zograf,** *ITMO University, Russia* • **Katerina Volodina,** *ITMO University, Russia* • **Andrey Krasilin,** *ITMO University, Russia* • **Vladimir Vinogradov,** *ITMO University, Russia* • **Sergey Makarov,** *ITMO University, Russia* The control of various processes at nanoscale in real time and easy manner is a challenge for different applications: from lab-on-a-chip to catalysis and medical diagnostic systems. Here, we demonstrate a new system, representing a metal-dielectric (hybrid) nanocavity for multifunctional sensing at nanoscale. The cavity provides enhancement of Raman signal and simultaneous control of temperature. We believe, the proposed concept provides a universal optical tool not only for the basic life sciences, but also for nanotechnology and nanomedicine.	
15:30 - 16:00	**COFFEE BREAK (THURSDAY AFTERNOON)**	
16:00 - 17:30	**ORAL SESSIONS (THURSDAY - AFTERNOON 2)**	
16:00	**CHIRALITY AND BIANISOTROPY** Session chairperson: Brian Stout	**TUNABLE AND ACTIVE METAMATERIALS** Session chairperson: Natalia Litchinitser
16:00 - 16:15	**Anomalous Surface-Wave Guiding on Omega-Bianisotropic Metasurfaces** **Extended oral :** • **Ariel Epstein,** *Technion - Israel Institute of Technology, Israel* We introduce a novel concept for anomalous surface-wave (SW) guiding on penetrable omega-bianisotropic metasurfaces, designed to guide a pair of SWs on each of their facets. The eigenmode is thus a quadruple of SWs, exchanging power via the metasurface while propagating along it. Full-wave simulations verify that these eigenmodes can be efficiently excited by a localized source, and the SW interference allows intricate manipulation of near-field features, holding potential for wireless power transfer and biomedical imaging applications.	**Generalized Huygens' Metasurface Based on Higher Order Magnetic Dipolar Resonances** • **Polina Kapitanova,** *ITMO University, Dept. of Nanophotonics and Metamaterials, Russia* • **Andrey Sayanskiy,** *ITMO University, Dept. of Nanophotonics and Metamaterials, Russia* • **Pavel Belov,** *ITMO University, Dept. of Nanophotonics and Metamaterials, Russ* • **Andrey Miroshnichenko,** *Australian National University, Nonlinear Physics Center, Research School of Physics and Engineering, Australia* All-dielectric Huygens' metasurface composed of cubic-shape unit cells supporting higher order magnetic resonances is demonstrated. Due to the combination of the electric and magnetic Mie-type multipolar resonances in one unit cell the metasurface exhibits an evident multimode interference with three pronounced maxima/minima in the transmission/reflection spectrum together with the multimode unidirectional scattering when the Kerker conditions are satisfied.

16:15 - 16:30

Random metamaterial at high filling factor

- **Nicolas Fernez,** *University of Lille, France*
- **David Dereudre,** *University of Lille, France*
- **Jianping Hao,** *University of Lille, France*
- **Éric Lheurette,** *University of Lille, France*
- **Didier Lippens,** *University of Lille, France*

The effect of high filling factor on electromagnetic properties of disordered resonator arrays with random positions are studied through analytical, numerical and experimental investigations. First, special attention was paid to the formation of dimer- and trimer-like clusters whose density dependence is analyzed via closed-forms by assuming a Poisson distribution of the ring centers. Then, the tradeoffs in the absorption spectrum are pointed out by a full wave analysis of the absorbance-band product. At last, an experimental evidence of a transition regime between isolated and clustered resonator is pointed out by experimental characterization of steel-ring arrays resonating at microwave frequency bands.

16:30 - 16:45

Disordered metamaterial asborbers at THz

- **Nicolas Fernez,** *University of Lille, France*
- **Fréderic Garet,** *University Savoie Mont Blanc, France*
- **Christophe Boyaval,** *University of Lille, France*
- **Éric Lheurette,** *University of Lille, France*
- **Jean-Louis Coutaz,** *University of Lille, France*
- **Didier Lippens,** *University of Lille, France*

Metamaterial absorbers made with micro-resonators randomly distributed onto a dielectric layer are a way to increase the absorbance bandwidth compared to periodic media. Numerical simulations show this effect at 300 GHz. A preliminary experimental assessment was conducted at 200 GHz with 500 Qm-size aluminum structures randomly placed onto a kapton dielectric layer with a back-side metal plate.

Wireless Power Transfer System Based on Colossal Permittivity Resonators

- **Mingzhao Song,** *ITMO University, Russia*
- **Polina Kapitanova,** *ITMO University, Russia*

We proposed novel dielectric resonators with colossal permittivity "=1000 for wireless power transfer. Numerical simulation and experimental investigation of the WPT system efficiency are performed. The highest power transfer efficiency of 90% at 232 MHz is verified experimentally.

16:45 - 17:00

Ultra-Thin Metasurface Absorbers for Spectro-Polarimetric Radiation Detectors: In-Depth Electromagnetic Analysis and Practical Design for Subterahertz Band

- **Sergei Kuznetsov,** *Novosibirsk State University, Russia*
- **Andrey Arzhannikov,** *Novosibirsk State University, Russia*
- **Victor Fedorinin,** *Institute of Semiconductor Physics SB RAS, Russia*

We present the results of extensive theoretical and

Non-Bianisotropic Complementary Split Ring Resonators Metasurfaces

- **Pablo Rodriguez Ulibarri,** *Universidad Pública de Navarra, Spain*
- **Irati Jáuregui,** *Universidad Pública de Navarra, Spain*
- **Miguel Beruete,** *Universidad Pública de Navarra, Spain*

A modified version of the complementary split ring resonator (CSRR), the nonbianistropic CSRR (NB-CSRR), is proposed as an angular selective

16:15 - 16:30

Electroluminescent Metamaterials

- **Quynh Le-Van,** *Université Paris-Saclay, Univ. Paris-Sud and CNRS, France*
- **Hongyue Wang,** *Université Paris-Saclay, Univ. Paris-Sud and CNRS, France*
- **Xavier Le Roux,** *Université Paris-Saclay, Univ. Paris-Sud and CNRS, France*
- **Abdelhanin Aassime,** *Université Paris-Saclay, Univ. Paris-Sud and CNRS, France*
- **Aloyse Degiron,** *Université Paris-Saclay, Univ. Paris-Sud and CNRS, France*

We introduce a class of active metamaterials based on combining semiconducting nanocrystals and metallic nanoparticles. We show that the electrical and optical properties of these devices are primarily defined by the inner nanoscale geometry of the structure, offering opportunities to create light-emitting structures of unprecedented complexity.

16:30 - 16:45

Optical Metasurfaces for Superposition of Twisted Light Beamss

- **Xianzhong Chen,** *School of Engineering and Physical Sciences, Heriot-Watt University, United Kingdom*
- **Fuyong Yue,** *School of Engineering and Physical Sciences, Heriot-Watt University, United Kingdom*
- **Shuang Zhang,** *School of Physics and Astronomy, University of Birmingham, United Kingdom*

We experimentally demonstrate a facile metasurface approach to manipulate superpositions of orbital angular momentum (OAM) states in multiple channels. Arbitrary control of the superpositions of various OAM states is realized by changing the polarization state of the incident light.

Tunable Plasmonic Structures Utilizing Liquid Crystals

- **Bernhard Atorf,** *University of Paderborn, Germany*
- **Hoda Rasouli,** *University of Paderborn, Germany*
- **Roman Rennerich,** *University of Paderborn, Germany*
- **Holger Mühlenbernd,** *University of Paderborn, Germany*
- **Bernhard Johannes Reineke,** *University of Paderborn, Germany*
- **Thomas Zentgraf,** *University of Paderborn, Germany*
- **Heinz Kitzerow,** *University of Paderborn, Germany*

Plasmonic nanostructures can be embedded in liquid crystals (LCs) to adjust the optical properties. Earlier works are reviewed and results of electro-optic and opto-optic experiments are presented, which demonstrate various switching opportunities of plasmonic resonators and holograms using LC mesophases, including both non-chiral and chiral nematic or smectic (ferroelectric) LCs.

16:45 - 17:00

Near-Field Chiral Interactions in Metamaterials

- **Lauren E. Barr,** *University of Exeter, United Kingdom*
- **Simon A. R. Horsley,** *University of Exeter, United Kingdom*
- **Jake Eager,** *University of Exeter, United Kingdom*
- **Cameron Gallagher,** *University of Exeter, United Kingdom*
- **Ian R. Hooper,** *University of Exeter, United Kingdom*
- **Samuel M. Hornett,** *University of Exeter, United Kingdom*

Spectrally Tunable Linear Polarization Rotation Using Stacked Metallic Metamaterials

- **Xavier Romain,** *FEMTO-ST Institute, France*
- **Fadi Baida,** *FEMTO-ST Institute, France*
- **Philippe Boyer,** *FEMTO-ST Institute, France*

A stack of metallic metamaterials is able to achieve either broadband or extremely narrowband polarization rotation, with perfect transmission. The arrangement of the structure allows for the spectrally tunable perfect transmission. These results can be used to develop versatile multilayer structures for the experimental investigations of high-performance ultra-thin metasurface-based radiation absorbers designed for narrow-band operation at subterahertz (subTHz) frequencies and intended for integration with spectro-polarimetric sensors of a thermal type. Implemented in a three-layered configuration with a capacitive frequency selective surface (FSS) backed by a grounded dielectric slab, the absorbers are analyzed in terms of minimizing their thickness-to-wavelength (d/lambda) ratio and absorption bandwidth, while maximizing the FSS unit cells subwavelengthness and free dispersion range for absorption spectra. A choice of optimal material parameters and a role of near-field "FSS – ground plane" coupling are discussed and an optimal FSS pattern for a "spectrometric" absorber is deduced. Supplemented with experimental measurements in the range of 0.1-1 THz demonstrating feasibility of attaining d/lambda-1/200 at the bandwidth of several percent, original cost-effective metasurface-absorber-based schemes for uncooled thermal subTHz sensing with spectrometric, polarimetric, and imaging capabilities are also considered.

metasurface. By joining the internal and external rings, the magnetic response of the classical CSRR is inhibited leading to a structure that is opaque under normal incidence and TE polarized waves. High transmission peaks can be only present under TM oblique incidence. Simulation and experimental results of a bi-layer NB-CSRR structure are presented in this work.

17:00 - 17:15

Absorptive Weakly Reflective Metamaterial Based On Optimal Rectangular Omegas

- **Igor Semchenko,** *Gomel State University, Belarus*
- **Sergei Khakhomov,** *Gomel State University, Belarus*
- **Andrey Samofalov,** *Gomel State University, Belarus*
- **Maxim Podalov,** *Gomel State University, Belarus*
- **Alexei Balmakou,** *Gomel State University, Belarus*
- **Elena Naumova,** *Rzhanov Institute of Semiconductor Physics, Russia*
- **Sergei Golod,** *Rzhanov Institute of Semiconductor Physics, Russia*
- **Victor Prinz,** *Rzhanov Institute of Semiconductor Physics, Russia*

A metamaterial absorber is realized for microwave and terahertz ranges using two-dimensional bianisotropic omega-elements by thorough analysis of their distribution on substrate as well as properly choosing omega's geometrical and material parameters. Simulations and experimental studies of the metamaterial confirm its low reflectance in a wide microwave range and high absorbance at the resonance.

A High-Low Impedance Low-Pass Filter Based on 1D Metamaterial Acting as Slow-Wave Microstrip Line

- **Heba El-Halabi,** *Beirut Arab University, Lebanon*
- **Hamza Issa,** *Beirut Arab University, Lebanon*
- **Darine Kaddour,** *Université Grenoble Alpes, LCIS, France*
- **Emmanuel Pistono,** *Université Grenoble Alpes, IMEP-LAHC, France*
- **Soubhi Abou-Chahine,** *Beirut Arab University, Lebanon*
- **Phillipe Ferrari,** *Université Grenoble Alpes, IMEP-LAHC, France*

This paper presents a miniaturized stepped impedance low-pass filter based on slow-wave microstrip transmission lines. The slow-effect effect is achieved by embedding metallic vias in the lower substrate layer of a double PCB substrate. Based on this concept, a miniaturized filter with a -3dB cut-off frequency of 2.45 GHz is designed realized and measured. Thanks to the slow-wave effect, 41% size miniaturization is achieved as compared to conventional microstrip filter prototype. The measured filter performance present a return loss of better than 20 dB and an insertion loss of 0.25 dB in the pass band.

- **Alastair P. Hibbins,** *University of Exeter, United Kingdom*
- **Euan Hendry,** *University of Exeter, United Kingdom*

Defining a chiral electromagnetic field as parallel electric and magnetic fields with a pi/2 phase difference, we study the importance of non-local effects in near-field interactions between an array of chiral antennas and a metamaterial comprised of sub-wavelength metallic helices.

control of light in the terahertz fingerprint.

17:00 - 17:15

3D-chiral Transparent Single-Crystal Silicon Metasurface for Visible Light

- **Maxim Gorkunov,** *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- **Oleg Rogov,** *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- **Alexey Kondratov,** *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- **Vladimir Artemov,** *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*
- **Alexander Ezhov,** *Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics", Russian Academy of Sciences, Russia*

We report a chiral dielectric metasurface with regular 3D nanorelief patterned by focused ion beam in a 300 nm thin single-crystal silicon film on sapphire. Upon annealing, the metasurface features a high transparency along with a circular dichroism and an optical activity reaching 0.5 and 20o respectively in the visible range, possesses crystal-grade hardness, chemical inertness of glass, and thermal stability of up to 1000 °C. The developed technique paves the way for new types of 3D-structured silicon meatsurfaces and metadevices.

Enhancing The Electrical Properties Of MoS2 Through Nonradiative Energy Transfer

- **John Gough,** *School of Physics and CRANN, Trinity College Dublin, Ireland, Ireland*
- **Maria O'Brien,** *School of Chemistry, CRANN and AMBER, Trinity College Dublin, Ireland, Ireland*
- **Niall McEvoy,** *School of Chemistry, CRANN and AMBER, Trinity College Dublin, Ireland, Ireland*
- **Alan Bell,** *School of Chemistry, CRANN and AMBER, Trinity College Dublin, Ireland, Ireland*
- **Georg Duesberg,** *School of Chemistry, CRANN and AMBER, Trinity College Dublin, Ireland, Ireland*
- **Louise Bradley,** *School of Physics and CRANN, Trinity College Dublin, Ireland, Ireland*

In this study highly efficient nonradiative energy transfer from semiconductor quantum dots to monolayer MoS2 with an efficiency of -99% is demonstrated. MoS2 samples of varying layer thickness were electrically contacted and the optoelectronic performance of the devices was studied before and after adding quantum dots in a sensitizing layer.

17:15 - 17:30

Mushroom-type HIS as perfect absorber for two angles of incidence

- **Dmitry Zhirihin,** *Saint Petersburg State University of Information Technologies, Mechanics and Optics, Russia*
- **Konstantin Simovski,** *Saint Petersburg State University of Information Technologies, Mechanics and Optics, Aalto University, Russia*
- **Pavel Belov,** *Saint Petersburg State University of Information Technologies, Mechanics and Optics, Russia*
- **Stanislav Glybovski,** *Saint Petersburg State University of Information Technologies, Mechanics and Optics, Russia*

In this work we show analytically and numerically that a mushroom-type high-impedance metasurface with loaded vias is capable to absorb perfectly electromagnetic TM-polarized plane waves for two angles of incidence(for normal incidence and for oblique incidence with a selected angle). Using the non-local homogenization model we demonstrated this effect can be achieved due to the two types of losses: dielectric losses inthe substrate of the metasurface and ohmic losses in lumped loads connecting vias and a ground plane. Moreover, we have shown that the angle of perfect absorption under oblique incidence can be tuned by varying the complex impedance of the loads.

Models of graphene-based metamaterials for drug delivery

- **Tania Puvirajesinghe,** *Aix-Marseille Université, Institut Paoli Calmettes, CRCM, Cell Polarity, Cell signaling and Cancer, Marseille, F-13009, France*

We investigate diffusion of a peptide drug through Graphene Oxide (GO) membranes that are modeled as a porous layered laminate constructed from flakes of GO and other polymer based materials. Our experiments employ a peptide drug and show a tunable non-linear dependence of the peptide concentration upon time. This is confirmed using numerical simulations with a diffusion equation accounting for the photothermal degradation of fluorophores and an effective percolation model. Applications include sustained drug delivery, which is associated with significant clinical advantages such as reducing the cost of drug intervention procedures.

17:30 – 18:00	**CLOSING CEREMONY**
18:00 – 20:00	**SOCIAL EVENT**

17:15 - 17:30

Angled hole-mask colloidal lithography fabricated plasmonic chiral Au nano-hooks for conformational analysis of proteins

- **Gunnar Klös,** *Aarhus University, Denmark*
- **Duncan Sutherland,** *Aarhus University, Denmark*

I present a novel fabrication method for chiral nanoparticles. It uses a hole-mask colloidal lithography approach combined with angled evaporation to produce plasmonic Au nano-hooks. Those nano-hooks express significant circular dichroism (CD) responses which makes them promising candidates for plasmonically enhanced protein conformation analysis.

Optical pulling and pushing forces in PT-symmetric structures

- **Rasoul Alaee,** *Max Planck Institute for the Science of Light, Germany*
- **Johan Christensen,** *Instituto Gregorio Millan Barbany, Universidad Carlos III de Madrid, Spain*
- **Muamer Kadic,** *Institut FEMTO-ST, CNRS, Université de Bourgogne Franche-Comté, France*

We explore, for the first time, optical pulling/pushing force exerted on a bilayer made of balanced gain and loss known as PT-symmetric structures. The optical pulling/pushing force is explained in the context of PT-symmetry and exceptional point.

17:30 – 18:00	**CLOSING CEREMONY**
18:00 – 20:00	**SOCIAL EVENT**

Notes

METAMATERIALS'2017

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METAMATERIALS'2017

MARSEILLE | 28 AUG > 2 SEPT

Monday, 28th August

	Large Theater	Sc. Nat. Theater	Massiani Theater	Charve Theater
09:00 - 10:00	Plenary session I			
10:00 10:30	Coffee Break			
10:30 - 12:30	Special Session on Commer-cialization of Metamaterials	Mechanics I	Meta-surfaces I	Nano-antennas
12:30 14:00	Lunch Break			
14:00 - 15:30	Special Session on Microwave Metamaterials and Metasurfaces	Thermal Radiation and Effects	Plasmonics	Meta-materials for Antennas
15:30 16:00	Coffee Break			
16:00 - 18:00	Physical Review Journals Symposium	Biosen-sing and Bio Appli-cations	Acoustics I	Topological Effects and Light Spin
18 :00	18:00 : Meet-and-greet the Physical Review Editors followed by Welcome Reception			

Tuesday, 29th August

	Large Theater	Sc. Nat. Theater	Massiani Theater	Charve Theater
09:00 - 10:00	Plenary session II			
10:00 10:30	Coffee Break			
10:30 - 12:30	Theory and Modelling I	Mechanics II	Active Meta-materials	Meta-surfaces for Antennas
12:30 14:00	Lunch Break			
14:00 - 15:30	Special Session on Hydro-dynamic Meta-materials	Graphene Plasmonics	Topo-logical Materials	Theory and Modelling II
15:30 16:00	Coffee Break			
16:00 - 18:00	Nonlinear Effects	Acoustics II	Nature Research Symposiu m	Cloaking
18 :00	18:00 - 19:00 Nature Research Symposium : Round Table Discussion			

Wednesday, 30th August

	Large Theater	Sc. Nat. Theater	Massiani Theater	Charve Theater
09:00 - 10:00	Plenary session III			
10:00 10:30	Coffee Break			
10:30 - 12:30	Special Session on Mech-anical Meta-materials	Quantum Plasmonics and Super-conducting Meta-materials	Meta-surfaces II	Tunable, Reconfigu-rable and Nonlinear Meta-materials
12:30 14:00	Lunch Break			
14:00 - 15:30	Exotic Effects at Micro-waves	Optical Meta-materials	Transfor-mation Electro-magnetics	Optical Forces
15:30 16:00	Coffee Break Poster Session			
16:00 - 18:00	17:30 Theory and Modelling III 18:30	Scattering Engi-neering	Device Appli-cations I	Terahertz Waves
18 :00	19:30 - 23:30 Gala Dinner			

Thursday, 31st August

	Large Theater	Sc. Nat. Theater	Massiani Theater	Charve Theater
09:00 - 10:00	Plenary session IV			
10:00 10:30	Coffee Break			
10:30 - 12:30	Special Session on Homoge-nization	Special Session on Seismic Meta-materials	Special Session on Acoustic Meta-materials for Noise Reduction	Quantum and Extreme Meta-materials
12:30 14:00	Lunch Break			
14:00 - 15:30	Experi-mental techniquesfa brica-tion and characterizat ion	Hyper-bolic Meta-materials	Light Trapping	Time Varying Meta-materials
15:30 16:00	Coffee Break			
16:00 - 18:00	Absorbers	Device Appli-cations II	Chirality and Bianiso-tropy	Tunable and Active Meta-materials
18 :00	17:30 - 18:00 Closing Ceremony 18:00 - 20:00 Social Event			