11\textsuperscript{th} International Congress
on Engineered Material Platforms
for Novel Wave Phenomena

PROGRAM

http://congress2017.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 seism 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 de la 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/
Program

**Tuesday, 29th August** ....................................................... 38

- Plenary Session II ......................................................... 38
- Oral Sessions Tuesday 29 – Morning .................................. 38
- Oral Sessions Tuesday 29 – Afternoon 1 ................................. 44
- Oral Sessions Tuesday 29 – Afternoon 2 ................................ 50
- Nature Research Symposium: Round Table Discussion ............ 56

**Wednesday, 30th August** .................................................... 58

- Plenary Session III .......................................................... 58
- Oral Sessions Wednesday 30 – Morning ............................... 58
- Oral Sessions Wednesday 30 – Afternoon 1 ............................ 66
- Poster Session .................................................................. 72
- Oral Sessions Wednesday 30 – Afternoon 2 ............................ 90
- Gala Dinner ........................................................................ 94

**Thursday, 31st August** ......................................................... 96

- Plenary Session IV ............................................................. 96
- Oral Sessions Thursday 1 – Morning ..................................... 96
- Oral Sessions Thursday 1 – Afternoon 1 ................................. 104
- Oral Sessions Thursday 1 – Afternoon 2 ................................. 110
- Closing Ceremony ............................................................. 116
- Social Event ...................................................................... 116

Notes ................................................................................. 118

---

**Metamaterials 2017**

Support, Sponsors, Exhibitors

**Organizational support**

![Organizational support Logo]

**Diamond sponsor**

<table>
<thead>
<tr>
<th>Logo</th>
<th>Name</th>
</tr>
</thead>
</table>
| ![APS Logo](http://www.journals.aps.org/) | American Physical Society


**Gold sponsors**

<table>
<thead>
<tr>
<th>Logo</th>
<th>Name</th>
</tr>
</thead>
</table>
| ![Nature Logo](http://www.nature.com/nature/index.html) | Nature
| ![Nature Materials Logo](http://www.nature.com/nmat/) | Nature Materials
| ![Nature Photonics Logo](http://www.nature.com/nphoton/index.html) | Nature Photonics
| ![Nature Communications Logo](http://www.nature.com/ncomms/) | Nature Communications
| ![Nature Reviews Materials Logo](https://www.nature.com/natrevmats/) | Nature Reviews Materials

Please visit their respective websites for more information.
Foreword

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, General 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 Review 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 fruitful discussions with colleagues and friends and to stay updated with the latest 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 marine 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 metamaterials.

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

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
<table>
<thead>
<tr>
<th>Committees</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPONSOR AND EXHIBITOR ORGANIZER</strong></td>
</tr>
<tr>
<td>Francesco Monticone, USA</td>
</tr>
<tr>
<td><strong>STUDENT PAPER COMPETITION AND BEST PAPER AWARDS</strong></td>
</tr>
<tr>
<td>Vincenzo Galdi, Italy (Chair)</td>
</tr>
<tr>
<td><strong>TECHNICAL SPONSOR ORGANIZER</strong></td>
</tr>
<tr>
<td>Davide Ramaccia, Italy</td>
</tr>
<tr>
<td><strong>WEB AND IT ADMINISTRATOR</strong></td>
</tr>
<tr>
<td>Paolo Carbone, Italy</td>
</tr>
<tr>
<td><strong>SCIENTIFIC ADVISORY BOARD</strong></td>
</tr>
<tr>
<td>Philippe Barois, France</td>
</tr>
<tr>
<td>Allan Boardman, UK</td>
</tr>
<tr>
<td>Andrey N. Lagarkov, Russia</td>
</tr>
<tr>
<td>Ross McPhedran, Australia</td>
</tr>
<tr>
<td>Birmel Ozbay, Turkey</td>
</tr>
<tr>
<td>John B. Pehnry, UK</td>
</tr>
<tr>
<td>Vlad Shalaev, USA</td>
</tr>
<tr>
<td>Ari Sihvola, Finland</td>
</tr>
<tr>
<td>Costas M. Soukoulis, Greece/USA</td>
</tr>
<tr>
<td><strong>REVIEWERS</strong></td>
</tr>
</tbody>
</table>
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.

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).
**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 appetizers 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**
**Social Events**

---

**Metamaterials 2017**
**Sessions Matrix**

**Monday, 28th August**

<table>
<thead>
<tr>
<th>Time</th>
<th>Grand Amphi Large Theater</th>
<th>SCIENCES NAT Theater</th>
<th>MASSIANI Theater</th>
<th>CHARVE Theater</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:45 – 09:00</td>
<td>Opening Ceremony</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09:00 – 10:00</td>
<td>Plenary Session I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 – 10:30</td>
<td>Coffee Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:30 – 12:30</td>
<td>Special Session on Commercialization of Metamaterials</td>
<td>Mechanics I</td>
<td>Metasurfaces I</td>
<td>Nanocantennas</td>
</tr>
<tr>
<td>12:30 – 14:00</td>
<td>Lunch Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14:00 – 15:30</td>
<td>Special Session on Microwave Metamaterials and Metasurfaces</td>
<td>Thermal Radiation and Effects</td>
<td>Plasmonics</td>
<td>Metamaterials for Antennas</td>
</tr>
<tr>
<td>15:30 – 16:00</td>
<td>Coffee Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:00 – 18:00</td>
<td>Physical Review Journals Symposium</td>
<td>Biosensing and Bio Applications</td>
<td>Acoustics I</td>
<td>Topological Effects and Light Spin</td>
</tr>
<tr>
<td>18:00 – 19:30</td>
<td>Welcome Reception</td>
<td>Meet-and greet the Physical Review Editors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Tuesday, 29th August

<table>
<thead>
<tr>
<th>Time</th>
<th>Grand Amphitheater</th>
<th>SCIENCES NAT theater</th>
<th>MASSIANI theater</th>
<th>CHARVE theater</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00 – 10:00</td>
<td>Plenary Session II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 – 10:30</td>
<td>Coffee Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:30 – 12:30</td>
<td>Theory and Modelling I</td>
<td>Mechanics II</td>
<td>Active Metamaterials</td>
<td>Metasurfaces for Antennas</td>
</tr>
<tr>
<td>12:30 – 14:00</td>
<td>Lunch Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14:00 – 15:30</td>
<td>Special Session on Hydrodynamic Metamaterials for Maritime Engineering</td>
<td>Graphene Plasmonics</td>
<td>Topological Materials</td>
<td>Theory and Modelling II</td>
</tr>
<tr>
<td>15:30 – 16:00</td>
<td>Coffee Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:00 – 18:00</td>
<td>Nonlinear Effects</td>
<td>Acoustics II</td>
<td>Nature Research Symposium: Metamaterials and Grand Challenges</td>
<td>Cloaking</td>
</tr>
<tr>
<td>18:00 – 19:00</td>
<td>Nature Research Symposium: Round Table Discussion</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Wednesday, 30th August

<table>
<thead>
<tr>
<th>Time</th>
<th>Grand Amphitheater</th>
<th>SCIENCES NAT theater</th>
<th>MASSIANI theater</th>
<th>CHARVE theater</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00 – 10:00</td>
<td>Plenary Session III</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 – 10:30</td>
<td>Coffee Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:30 – 12:30</td>
<td>Special Session on Mechanical Metamaterials</td>
<td>Quantum Plasmonics and Superconducting Metamaterials</td>
<td>Metasurfaces II</td>
<td>Tunable, Reconfigurable and Nonlinear Metamaterials</td>
</tr>
<tr>
<td>12:30 – 14:00</td>
<td>Lunch Break</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14:00 – 15:30</td>
<td>Exotic Effects at Microwaves</td>
<td>Optical Metamaterials</td>
<td>Transformation Electromagnetics</td>
<td>Optical Forces</td>
</tr>
<tr>
<td>17:30 – 18:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19:30 – 23:30</td>
<td>Gala Dinner</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Metamaterials 2017**

**Session Matrix**

**Thursday, 31st August**

<table>
<thead>
<tr>
<th>Time</th>
<th>Venue</th>
<th>Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00 – 10:00</td>
<td>Grand Amphi large theater</td>
<td>Plenary Session IV</td>
</tr>
<tr>
<td>10:00 – 10:30</td>
<td></td>
<td>Coffee Break</td>
</tr>
<tr>
<td>10:30 – 12:30</td>
<td></td>
<td>Special Session on Homogenization, Special Session on Seismic Metamaterials, Special Session on Acoustic Metamaterials for Noise Reduction, Quantum and Extreme Metamaterials</td>
</tr>
<tr>
<td>12:30 – 14:00</td>
<td></td>
<td>Lunch Break</td>
</tr>
<tr>
<td>14:00 – 15:30</td>
<td></td>
<td>Experimental techniques, fabrication and characterization of metamaterials, Hyperbolic Metamaterials, Light Trapping, Time Varying Metamaterials</td>
</tr>
<tr>
<td>15:30 – 16:00</td>
<td></td>
<td>Coffee Break</td>
</tr>
<tr>
<td>16:00 – 17:30</td>
<td></td>
<td>Absorbers, Device Applications II, Chirality and Birefringent Metamaterials, Tunable and Active Metamaterials</td>
</tr>
<tr>
<td>17:30 – 18:00</td>
<td></td>
<td>Closing Ceremony</td>
</tr>
</tbody>
</table>

**Monday, 28th August**

<table>
<thead>
<tr>
<th>Time</th>
<th>Venue</th>
<th>Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>07:45 - 08:45</td>
<td></td>
<td>MONDAY REGISTRATION</td>
</tr>
<tr>
<td>08:45 - 09:00</td>
<td></td>
<td>OPENING CEREMONY</td>
</tr>
<tr>
<td>09:00 - 10:00</td>
<td></td>
<td>PLENARY SESSION 1</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td></td>
<td>COFFEE BREAK (MONDAY MORNING)</td>
</tr>
<tr>
<td>10:30 - 12:30</td>
<td></td>
<td>ORAL SESSIONS (MONDAY MORNING)</td>
</tr>
</tbody>
</table>

**Program**

**Sunday, 27th August**

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:00 - 18:00</td>
<td>SUNDAY REGISTRATION, Café L’Ecomotive, 2 Place des Marseillaises, 13001 Marseille</td>
</tr>
</tbody>
</table>

**Monday, 28th August**

**PLENARY SESSION 1**

- 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.
## Metamaterials 2017

### Program

**Monday**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Invited oral:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30</td>
<td>SPECIAL SESSION ON COMMERCIALIZATION OF METAMATERIALS</td>
<td>Nathan Kundtz, Aymetacorp, USA</td>
</tr>
<tr>
<td>10:30 - 11:00</td>
<td>MECHANICS I</td>
<td>Tobias Frenzel, Institute of Applied Physics and Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Germany; Muamer Kundic, FEMTO-ST, CNRS, Université Bourgogne Franche-Comté, France; Martin Wegener, Institute of Applied Physics and Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Germany</td>
</tr>
<tr>
<td>11:00 - 11:30</td>
<td>METASURFACES I</td>
<td>John Pendry, Imperial College London, United Kingdom</td>
</tr>
<tr>
<td>11:00 - 11:30</td>
<td>NANOANTENNAS</td>
<td>Mohsen Rahmani, Australian National University, Australia; Dragomir Neshev, Australian National University, Australia</td>
</tr>
</tbody>
</table>

**Experiments on 3D Micropolar Metamaterials**

- 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 metamaterial-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.

**High-efficiency surface plasmon meta-couplers**

- 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.

**Surface plasmons and metasurfaces**

- 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.

**Metamaterials Electronically Scanning Array: Design of Imaging Radars for Autonomous Vehicles**

- 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 approaches to beam steering. This approach allows very high efficiencies.

**High-efficiency surface plasmon meta-couplers**

- Although surface plasmon polaritons (SPPs) have found numerous applications in photonics, how to efficiently excite them remains a grand challenge. 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.

**Novel Topological Concepts for Reliable Mechanical Wave-guiding**

- We discuss novel concepts for reliable mechanical wave-guiding based on 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.

**High-efficiency surface plasmon meta-couplers**

- We propose a new mechanism to efficiently couple SPPs with free-space light based on artificial gradient metamaterials. Specifically, we demonstrate how to realize surface plasmon polaritons (SPPs) with efficiency in the range of 70%. This is achieved by utilizing the high refractive index contrast of the artificial gradient metamaterials, which enables the efficient coupling of SPPs with free-space light. The efficiency of the coupling is achieved by taking advantage of the high refractive index contrast of the artificial gradient metamaterials, which results in a highly efficient excitation of SPPs with free-space light. This mechanism enables the efficient coupling of SPPs with free-space light, which is a critical step towards the realization of high-efficiency surface plasmon polariton (SPP) devices.
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 sizable 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 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 portions of the design cycle utilized for MESA, and present a semi-analytic technique developed in-house for modeling beam-forming and array-factor portions of the design cycle utilized for MESA, and present a semi-analytic technique developed in-house for modeling beam-forming and array-factor portions of the design cycle utilized for MESA, and present a semi-analytic technique developed in-house for modeling beam-forming and array-factor. We also present test results from one such example, a MESA radar product designed to enable 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 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 affordability. Specifically, we focus on the technique of rolling lithography, which can produce nanopatterned surfaces over meter-long lengths.

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

Invited oral:
- Themos Kallos, Metamaterial Technologies Inc, Canada
- George Paliakas, Metamaterial Technologies Inc, Canada
- Nom,

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 affordability. 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
- 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

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 affordability. Specifically, we focus on the technique of rolling lithography, which can produce nanopatterned surfaces over meter-long lengths.

Wavefront Rerouting with Super-Grating Metasurfaces

Invited oral:
- Andrea Ali, The University of Texas at Austin, USA
- Christophe Sauvan, Institut d’optique Graduate School, France
- Jean-Jacques Greffet, Institut d’optique Graduate School, France

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 affordability. Specifically, we focus on the technique of rolling lithography, which can produce nanopatterned surfaces over meter-long lengths.

Boosting the electrical generation of surface plasmons polaritons with optical nanoantennas

Invited oral:
- Cheng Zhang, Institut d'optique Graduate School, France
- Jean-Paul Hugonin, Institut d'optique Graduate School, France
- Andrea Ali, The University of Texas at Austin, USA
- Christophe Sauvan, Institut d’optique Graduate School, France
- Jean-Jacques Greffet, Institut d’optique Graduate School, France

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 affordability. Specifically, we focus on the technique of rolling lithography, which can produce nanopatterned surfaces over meter-long lengths.
<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
</table>
| 11:45 - 12:00 | Topological Transport Of Rotational Waves in Mechanical Granular Graphene  
- Li-Yang Zheng, LAUM, UMR-CNRS 6615, 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. |
| 12:00 - 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 IOT, micro-Doppler sensors for breathing detection, and peripheral nerves/brain focused magnetic stimulation (TMS) 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/5G LTE/5G communications. In my talk, I will give an overview of our innovation/strategic agenda, and our efforts to commercialize metamaterials. |
| 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 tuning of their properties. In this paper, we show how the advantages of glide symmetry can be mimicked in systems that are tunable through the application of an external field. The tunability of phononic crystals is achieved through the introduction of defect states that can be engineered to behave as gain media, thus allowing for the amplification of acoustic waves. In addition to tunability, phononic crystals also exhibit non-reciprocal properties, meaning that the propagation of waves in one direction is different from that in the opposite direction. These properties have numerous potential applications, from the design of novel acoustic filters to the development of new technologies for information processing and communication. |
| 12:45 - 12:00 | Highly-transparent all-dielectric metasurfaces with broadband response  
- Sergey Kruk, Australian National University, Australia  
- Lei Wang, Australian National University, Australia  
- Hanli Tang, Australian National University, Australia  
- Ben Hopkins, Australian National University, Australia  
- Andrei Miroshnichenko, Australian National University, Australia  
In this contribution, we report on the development of highly-transparent all-dielectric metasurfaces with broadband performance. These metasurfaces are based on the design of lossless all-dielectric nanoparticles that can be tuned by the application of an external electric field. The broadband response is achieved through the use of a novel design that exploits the interplay between the plasmonic and dielectric response of the nanoparticles. The metasurfaces are demonstrated to exhibit high transmittance and low absorption across a broad frequency range, making them suitable for applications in a wide range of fields, such as optical communications, thermophotovoltaics, and photodetection. |
| 12:00 - 12:15 | Optical metasurfaces based on plasmonic nanoparticles for anti-reflection coatings and transparent absorbers  
- Alessio Monti, Niccolò Cusano University, Italy  
- Andrea Alu, University of Texas at Austin, USA  
- Alessandro Toscano, Roma Tre University, Italy  
- Pierfrancesco Bilotti, Roma Tre University, Italy  
In this contribution, we demonstrate 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 cloak-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. |
| 12:15 - 12:30 | Coupled Slot Metasurfaces With Spof Glide Symmetry  
- Miguel Camacho, University of Exeter, United Kingdom  
- Alistair P. Hibbins, University of Exeter, United Kingdom  
- Oscar Quevedo-Teruel, KTH Royal Institute of Technology, Sweden  
In this paper, we present a new class of coupled slot metasurfaces that exhibit glide symmetry. These metasurfaces are designed to support surface waves that exhibit rapid switching between forward and backward propagation. The key to achieving this is the use of a novel design that exploits the interaction between two types of surface waves: in-gap plasmon and spoof plasmon. The in-gap plasmon wave supports a low-loss surface wave with high electric field in the air between the two slabs, while the spoof plasmon wave supports a high-loss surface wave with high electric field in the gap. By carefully tailoring the geometry and material properties of the metasurfaces, we are able to achieve a large degree of switching between these two modes. This allows for a new class of devices that can be used in a variety of applications, including photonic switching and plasmonic signal processing. |
| 12:45 - 12:00 |  
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 | Switchable directional excitation surface plasmon polaritons with dielectric nanonantennas  
- Ivan Sinev, ITMO University, Russia  
- Filipp Komissarenko, ITMO University, St. Petersburg Academic University, Russia  
- Andrey Bogdanov, ITMO University, Russia  
- Mikhail Petrov, ITMO University, Russia  
- Kristina Fitzzh, ITMO University, Russia  
- Sergey Makanov, ITMO University, Russia  
- Omar Mhurtin, ITMO University, St. Petersburg Academic University, Russia  
- Anton Samusev, ITMO University, Russia  
- Andrei Lavrinenko, ITMO University, Technical University of Dortmund, Russia, Denmark  
- Andrey Miroshnichenko, Australian National University, Australia  
We demonstrate directional launching of surface plasmon polaritons on thin gold film with a single silicon nanosize. 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 nanonantennas.  
| 12:15 - 12:30 | Unveiling Magnetic and Chiral Nanoscale Properties Using Structured Light and Nanonantennas  
- Jinwei Zeng, University of California, Irvine, USA  
- Mohammad Albooyeh, University of California, Irvine, USA  
- Mahsa Darvishzadeh-Varche, University of California, Irvine, USA  
- Mohammad Kamandi, University of California, Irvine, USA  
We experimentally demonstrate that a single-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.  

control of their properties, what inhibits them from 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.

### ORAL SESSIONS (MONDAY - AFTERNOON 1)

#### SPECIAL SESSION ON MICROWAVE METAMATERIALS AND METASURFACES
Organizers: Ariel Epstein; Ekaterina Shamonina; Francisco Medina
Session chairperson: Ariel Epstein

**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
- Pingjian 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 exceeding 10 MHz. We expect to modulate thermal emission at a rate approaching unity. This type of design allows to produce thermal emission with an effective emissivity 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.

Tailoring Absorption and Thermal Emission with Metasurfaces

Invited oral:
- Jean-Jacques Greffet, Institut d’Optique, France
- Lao Wojcieszczk, Institut d’Optique, France
- Emille Sakat, Institut d’Optique, France
- Ioana Doyen, Institut d’Optique, France
- Anne-Lise Coutrot, Institut d’Optique, France
- Francois Marquenie, 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.

### THERMAL RADIATION AND EFFECTS

Session chairperson: Igor Nefedov

**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 Shein, Purdue University, USA
- Alexandra Boltasseva, Purdue University, USA

In ultra-thin plasmonic films, approaching only a few nanometers 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 California, Irvine, USA
- Mohsen Raajie, University of California, Irvine, USA

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 (HIP) to mitigate any cross talk between adjacent antennas; and passive and active circuits including wide bandwidth and conformal amplifiers, bias-taps, 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.
Optimization-Based Design Of Thermal Metamaterials
• Ignacio Peralta, CIMEC (UNL/CONICET), Argentina
• Victor 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 virtual 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 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 Alwali, Institut Fresnel, France
• Myriam Zeraa, 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.

3D printed metamaterial based substrates
• Darren Cadman, Loughborough University, United Kingdom
• Shuya Zhang, Loughborough University, United Kingdom
• William Whitlow, Loughborough University, United Kingdom
• Yanais Vardaxoglou, Loughborough University, United Kingdom
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 amorphous silver ink. The selective permissivity 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

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 Gelivand, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia
• Serguei Pati, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia

Hybrid optical nanostructures composed of metallic nanohole 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 Billotti, “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 circulary-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.

Tunable Epsilon near-zero chalcogenides
• Behrad Ghoshpour, 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 & Centre for Disruptive Photonic Technologies, School of Physical and Mathematical Sciences & The Photonics Institute, Nanyang Technological University, Singapore
• Vladimir Artemov, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia

The enormous potential of chalcogenides as compositionally-tuneable alternatives to noble metals for plasmonics and epsilon-near-zero (ENZ) photonics can be unlocked using tight-throughput 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.

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 Gelivand, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia
• Serguei Pati, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia

Hybrid optical nanostructures composed of metallic nanohole 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 Billotti, “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 circulary-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.

Tunable Epsilon near-zero chalcogenides
• Behrad Ghoshpour, 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 & Centre for Disruptive Photonic Technologies, School of Physical and Mathematical Sciences & The Photonics Institute, Nanyang Technological University, Singapore
• Vladimir Artemov, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia

The enormous potential of chalcogenides as compositionally-tuneable alternatives to noble metals for plasmonics and epsilon-near-zero (ENZ) photonics can be unlocked using tight-throughput 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.

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 Gelivand, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia
• Serguei Pati, Shubnikov Institute of Crystallography, Federal Scientific Research Centre “Crystallography and Photonics”, Russian Academy of Sciences, Russia

Hybrid optical nanostructures composed of metallic nanohole 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 Billotti, “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 circulary-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.
### Microwave Metasurfaces with Honeycomb Symmetry

**15:00 - 15:15**

- **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.

### Thermally Tunable Infrared Metasurfaces

**15:15 - 15:30**

- **David Shkrekenhamer,** 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 sulfide (GeS)—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 absorptance 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.

### Shaping The Spectral And Spatial Emissivity With Plasmonic Nano-Antennas

**15:00 - 15:15**

- Mathilde Makhalyan, MINAO - ONERA - The French Aerospace Lab, France
- Patrick Bouchon, MINAO - ONERA - The French Aerospace Lab, France
- Julien Jaack, MINAO - ONERA - The French Aerospace Lab, France
- Riad Haidar, Univ. Blaise Pascal, Inst. Pascal, France
- Julien Jaeck, MINAO - ONERA - The French Aerospace Lab, France
- Pinelishe Chaklad, MINAO - ONERA - The French Aerospace Lab, France
- Emmanuel Centeno, Université Blaise Pascal, Institut Pascal, France
- Alexandre Moreau, Université Blaise Pascal, Institut Pascal, France
- Armel Pitelet, Université Blaise Pascal, Institut Pascal, France
- Mathilde Makhsiyan, King’s College London, United Kingdom
- Vitaly V. Zayats, King’s College London, United Kingdom

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.

### Field enhancement in strongly-coupled plasmonic nanocone metamaterials

**15:15 - 15:30**

- B. Margoth Cárdeno-Castro, King’s College London, United Kingdom
- Alexey V. Kravtsov, 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 nancone metamaterial, which can be fabricated using a new scalable manufacturing procedure by ion etching of Au nanorods.

### Revealing the Influence of Non-Locality on Plasmonic Systems

**15:00 - 15:15**

- Aramel Pitalet, Universiti Blaise Pascal, Institut Pascal, France
- Antoine Moreau, Universiti Blaise Pascal, Institut Pascal, France
- Emmanuel Centeno, Universiti Blaise Pascal, Institut Pascal, France
- Sandrine Gottereau, Universiti Blaise Pascal, Institut Pascal, France
- Stefan Enoch, Aix-Marseille Universite, Institut Fresnel, France
- Christoph Vilmen, Aix-Marseille Universite, Center for Magnetic Resonance in Biology and Medicine, France
- Stanislav Glybovski, ITMO University, Russia
- Anton Nikulin, ITMO University, Russia
- Anna Kharkaulina, ITMO University, Russia
- Pavel Belov, ITMO University, Russia
- Inigo Ederra, Universitat Politècnica de Navarra, Spain

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 completely neglect this effect on the optical response of plasmonic devices.

### Metamaterial enhanced slotted waveguide antenna

**15:15 - 15:30**

- 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.
Detection of Molecule Chirality Based on Plasmonic Nanostructures and Metamaterials

**Invited oral:**
- S. Sadofev, Humboldt-Universität zu Berlin, Germany
- H. Memmi, Humboldt-Universität zu Berlin, Germany
- S. Kalusniak, Humboldt-Universität zu Berlin, Germany
- S. Kalusniak, Humboldt-Universität zu Berlin, Germany
- Oliver Benson, Humboldt-Universität zu Berlin, Germany
- S. Sadofev, Humboldt-Universität zu Berlin, Germany
- S. Kalusniak, Humboldt-Universität 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 μm-thick films. This new hybrid state holds strong potential for application in chemistry and opto-electronics.
Nonreciprocal Quantum Optical Devices Based on Chiral Interaction between Atoms and Photons with Transverse Spin

- 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 matter therefore features chiral, i.e., propagation-direction-dependent, effects which are interesting both conceptually and for quantum-photonic applications.

On-chip Biosensing with Optical Nano-resonators

Invited oral:
- Roman Guidant, ICFO-Institut de Ciències Fotòniques, Spain
- O. Yavas, ICFO-Institut de Ciències Fotòniques, Spain
- Kh. Dobosz, ICFO-Institut de Ciències Fotòniques, Spain
- S. Acimovic, ICFO-Institut de Ciències Fotòniques, Spain
- V. Sanz Beltran, ICFO-Institut de Ciències Fotòniques, 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.

On the Design of Perfect Acoustic Metasurfaces

- Ana Díaz-Bribio, Aalto University, Finland
- Sergei Tret’yakov, 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 Acoustic Polaritons: Robust Sound Propagation in a Two-Dimensional (2D) 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 Normal University, China
- Xiao-Jun Liu, Nanjing Normal University, China

We experimentally demonstrate an acoustic spoof plasmon polariton 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.

Invisibility Cloaking Using Pseudomagnetic Field For Photon

- Fu Liu, Tsinghua University - Department of Physics and Astronomy, Univesity of Exeter, United Kingdom
- Jianli Li, Tsinghua University - Department 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 imaging with metasurfaces: from concept to human trials

Invited oral:
- Alena Shchelokova, ITMO University, Russia
- Rita Schmidt, Leiden University Medical Center, The Netherlands
- Alexey Stobozhanuy, 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 intelligence, offering unprecedented control over light and matter. In this talk, we will present recent advances in the field of metasurfaces and their applications in various domains, including biosensing, imaging, and communications.
Acoustic Metamaterial Configurations Based on Detuned Acoustic Resonators

- Sergey I. Bozhevolnyi, Centre for Nano Optics, University of Southern Denmark, Denmark
- 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
- Ian Young, Imperial College London, United Kingdom

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 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 Waddington, 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.

Topological Protected Sound Transmission in Flow-free Acoustic Metamaterial Lattice

- Zhizhang Zhang, Nanjing University, China
- Qi Wei, Nanjing Normal University, China
- Ying Cheng, Nanjing University, China
- Dajuan Wu, Nanjing Normal University, China
- Desheng Ding, Northeast 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.

An Acoustic Metamaterial Crystal With a Graphene-like Dispersion

- Simon Yves, Institute Langevin, France
- Fabrice Lamont, Institute Langevin, France
- Mathias Pint, Institute Langevin, France
- Geoffrey Lerosey, Institute 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

- Mikko Barbuto, “Niccolo Cusano” University, Italy
- Mohammad-All Miri, University of Texas at Austin, Department of Electrical and Computer Engineering, USA
- Andrea Aliu, 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.
Metamaterial MRI-based Surgical Wound Monitor
- Hanan Kamel, Imperial College London, United Kingdom
- Richard Syms, Imperial College London, United Kingdom
- Evi Kardeulaki, 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 biofragile 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.

Double Zero Index Acoustic Metamaterial
- Marc Dubois, UC Berkeley, USA
- Chengzhil 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.

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
Session chairperson: Mathias Fink

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

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.

10:30 - 10:45
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.

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. Koschev, 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.

10:30 - 10:45
ACTIVE METAMATERIALS
Session chairperson: Allan Boardman

10:30 - 10:45
Optimizing Information Gathering Capabilities of a Metasurface
Invited oral:
• David Smith, Duke University, USA
• Dan Marks, Duke University, USA
• Okan Yurduseven, Duke University, USA
• Mohammadneza 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 geometries.
Rayleigh limit of high-index dielectric nanowires

Ory Schnitzler, 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-far-fields 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:

Anastasia Krushynska, Department of Physics, University of Turin, Italy
Pedroco Bosia, Department of Physics, University of Turin, Italy
Marco Miniaci, 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.

Super-Resolution Imaging With Pulse Shaping

Andrei Rogov, Purdue University, USA
Evgueni 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.

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

Waqas Wassem Ahmed, Universitat Politècnica de Catalunya, Spain
Muriel Bény, Universitat Politècnica de Catalunya, Spain
Ramón Herrero, Universitat Politècnica de Catalunya, Spain
Kastalis Stallinas, 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.

Absorber-Laser Modes And Transparency in The Absence 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
Piotr Dlakos, 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, Università di Siena, Italy
Marco Paanzi, University of Siena, Italy
Francesco Caminita, University of Siena, Italy
Enrica Martin, Università 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 present a multi-source feeding scheme. The elements of the objective surface impedance tensor are defined in closed-form, and numerical results based on the Method of Moments are presented for validation.

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 Kros, 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
11:30 - 11:45
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 materials in the quasistatic regime.

11:45 - 12:00
Field Patterns: A New Type Of Wave

11:45 - 12:00

Strong Localization of Flexural Waves in Disordered Thin Plates

• Patrick Sébbah, CNRS - Institut Langevin & Bar Ilan University, France
• Gautier Lefebvre, CNRS - Institut Langevin, France
• Marc Dubols, CNRS - Institut Langevin, France
• Etienne Herth, CNRS-Paris-6T, 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.

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

• Domenico Talarico, 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 away from the lattice normal. The proposed method provides a smart tool to realize various functional devices and systems.

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 Granat, Institut Fresnel - CNRS, France

The analytical treatment of wave propagation in dispersive media requires handling branch-cuts in self-oscillating, tunable Fabry-Perot antenna with active metasurface, and verify it by measurements on 1D experimental demonstrator.

12:00 - 12:15

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 Sébbah, Bar Ilan University, Institut Langevin, ESPCI ParisTech, CNRS , Israel, France

Metasurface antennas: basic physics, design and synthesis

• Gabriele Minniti, University of Siena, Italy
• Enrica Martinelli, 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.

12:15 - 12:30
Exceptional Points of Degeneracy in Coupled Modes: Theory and Applications

• 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 Filipetti, 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.

12:30 - 12:45
Metamaterial Structures based on ‘Negative’ Elements: What Do We Know After a Decade of Research?

• Silvio Harbar, University of Zagreb, Croatia

Almost ten years have passed since the first experimental attempts of enhancing functionality of square metal sub-blocks for desirable performance. It is convenient to obtain 1-bit coding elements with the phase difference of 180° 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.

12:45 - 1:00
Invited oral:
• Filiberto Bilotti, Roma Tre University, Italy
• Alessandro Toscano, Roma Tre University, Italy

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

• Alessio Monti, Niccolò Cusano University, Italy
• Davide Ramacchia, Roma Tre University, Italy
• Andrea Aliu, 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 plasmonic 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.

Consider two materials with permittivities/dielectric constants 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 Lille 1, France
• Bernard Bonello, Institut des NanoSciences de Paris, CNRS 7588, Université Pierre et Marie Curie, France
• Bahram Dijari-Rouhani, Institut d’Electronique, de Microélectronique et de Nanotechnologie, UMR CNRS 8520, Université 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 homogenous 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.

of metamaterials by embedding 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 introduced.

Recently, the ideas of topological photonics were extended to plasmonic materials to manipulate the propagation of light through them. The topological protection of light ensures that the wave fronts of light are not distorted, even when the medium is scattering. This property is not limited to the transmission and reflection coefficients, but it also applies to the group velocity of the wave. This means that the waves propagate through the medium in a stable and predictable manner, even in the presence of disorder and turbulence. This is particularly relevant in applications such as optical interconnects, optical switches, and all-optical computing, where maintaining the integrity of the propagating light is crucial. 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.
Optical excitations sustained by atomic-scale 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 [4].

Drift-induced Spasing in Bilayer Graphene

We propose a tunable power splitter based on topological effect. In fact, we showed that cyclotron resonance of 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.

Topological THz Devices using Semiconductors

We presented experimental measurements of perfect absorption on surface water waves.

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’Université 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 absorptivity.

Topological Insulators Based on Coupled Nonlinear Resonators

Invited oral:

•  Andrea Ali, The University of Texas at Austin, USA
•  Yakir Haddad, 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 Vitiello, 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, electromagneticics, 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 optical continua that can be topologically classified.
### Removable Tsunami Wall Composed of Acoustic Eaton Lens Array

- Sang-Hoon Kim, Aix Marseille Univ, CNRS, Centrale Marseille, France
- O. Kimmoun, Aix Marseille Univ, CNRS, Centrale Marseille, France
- S. Enoch, Aix Marseille Univ, CNRS, Centrale Marseille, France
- B. Molin, Aix Marseille Univ, CNRS, Centrale Marseille, France
- F. Remy, Aix Marseille Univ, CNRS, Centrale Marseille, France

A removable tsunami wall made of expandable rubber pillars or balloons of acoustic Eaton lenses is proposed theoretically. The lens creates a stopband 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.

### Plasmon signatures of single molecules near graphene nanoflakes

- O. Kimmoun, University College London - EEE, United Kingdom
- S. Enoch, University College London - EEE, United Kingdom

### Material hybrid antennas of meta-atoms for additive manufacturing

- Yianilos Yardasgiou, 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](http://www.symeta.co.uk)
Tuesday

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.

COFFEE BREAK (TUESDAY AFTERNOON)

16:00 - 18:00 ORAL SESSIONS (TUESDAY - AFTERNOON 2)

16:00 NONLINEAR EFFECTS
Session chairperson: Nikolay Zheludev

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 University of State Morelos, Mexico
- Bertrand Kibler, Universite de Bourgogne, France
- Jim McNiff, Original Perspectives, United Kingdom
- Yuriy Rapoport, Texas 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.

16:00 - 16:30 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
- Yuriy Rapoport, Texas Shevchenko National University of Kyiv, Ukraine

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.

15:15 - 15:30 Photonic 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
- Olegien Ilie, California Institute of Technology, USA
- Deep M. Jariwala, California Institute of Technology, USA
- Michelle C. Sherratt, California Institute of Technology, USA
- Joeson Wong, California Institute of Technology, USA
- William Whitney, California Institute of Technology, USA
- Paloma Arroyo Huidobro, Imperial College London, United Kingdom
- Maria Maragkou, Roma Tre University, Italy
- Harry A. Atwater, California Institute of Technology, USA
- Olegien Ilie, California Institute of Technology, USA
- Deep M. Jariwala, California Institute of Technology, USA
- Michelle C. Sherratt, California Institute of Technology, USA
- Joeson Wong, California Institute of Technology, USA
- William Whitney, California Institute of Technology, USA
- Paloma Arroyo Huidobro, Imperial College London, United Kingdom

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.

15:15 - 15:30 Electromagnetic Cloaking for Antennas
Invited oral:
- Mirko Barbato, 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 Billot, 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 TEC 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. Kuhlmev, 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.

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.

16:30 - 16:45  Acoustic Metamaterials for Subwavelength Resolution Based on Transformation Acoustics
- Gangyong Song, Southeast University, China, China
- Giang Cheng, Southeast University, China, China

We propose a new approach to design acoustic metamaterials 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  Transformation Physics And Homogenization For Cloaking in Plates
- Lucas Pomet, 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
- Andrei Faraon, California Institute of Technology, USA
- Frederik Mayer, Karlsruhe Institit of Technology, Germany
- Andreas Naber, Karlsruhe Institit of Technology, Germany
- Miguel Beruete, Universidad Pública de Navarra, Spain
- Frederik Mayer, Karlsruhe Institit of Technology, Germany

Invited oral:

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 transmittantys and reflectantys 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, wavelplates, 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-reflector and Fourier lens systems with applications in ultracompact imaging systems. Applications in microscopy and the prospects for tunable devices are discussed.

16:45 - 17:00  Partial Coherence Uncloaks Diffusive Optical Invisibility Cloaks
- Andreas Niemeyer, Karlsruhe Institit of Technology, Germany
- Andreas Naber, Karlsruhe Institit of Technology, Germany
- Martin Wegener, Karlsruhe Institit of Technology, Germany

Within the range of validity of the stationary diffussion 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.

16:30 - 16:45  Transformation Based Diffusive-light Cloak for Transient Illumination
- Bakhtiyar Orazbaev, École Polytechnique Fédérale de Lausanne, Switzerland
- Miguel Beruete, Universidad Pública de Navarra, Spain
- Alejandro Martinez, 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.
Tuesday

17:00 - 17:15

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

• Flavia Timpu, ETH Zürich, Switzerland
• Claude Renaud, ETH Zürich, Switzerland
• Morgan Trasini, ETH Zürich, Switzerland
• Manfred Fleibig, ETH Zürich, Switzerland
• Rachel Grange, ETH Zürich, Switzerland

We measure the linear and the second harmonic generation (SHG) spectra of individual Barium Titanate (BaTiO3) 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 unpatterened layer of BaTiO3. We propose to improve the control of the size and shape of the nanoparticles by using BaTiO3 nanocylinders fabricated by focused ion beam (FIB) milling.

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
• Irya Akinov, TU Dortmund University, Germany
• Vladimir Belotelov, Russian Quantum Center, Russia
• Maciej Wiatr, Institute of Physics, Polish Academy of Sciences, Poland

We present how the full account of temporal dispersion and spacial dispersion leads to the precise description of effective-medium parameters of a photonic crystal made of periodic arrangement of rigid inclusions embedded in a viscous thermal 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.

Effective Properties of Phononic Crystals in Bragg Regime

• Navid Nemat, Laboratoire Modélisation et Simulation Multi Échelle, Université Paris-Est, France
• Camille Perrot, Laboratoire Modélisation et Simulation Multi Échelle, Université Paris-Est, France
• Denis Duhamel, Laboratoire Navier, Ecole des Ponts, France

We demonstrate the transverse magneto-optical Kerr effect in semiconductor nanostructures. It is studied how the TMOKE depends on the incident angle and external magnetic field. The nanostructures. It is studied how the TMOKE depends on the incident angle and external magnetic field. The latter: the Acoustic Dispersive Prism and the Single-Microphone Direction Finding.

17:30 - 17:45

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

• Hervé Lissek, École Polytechnique Fédérale de Lausanne, Switzerland
• Hussein Esfahlani, École Polytechnique Fédérale de Lausanne, Switzerland
• Jean-Raman Mosly, École Polytechnique Fédérale de Lausanne, Switzerland
• Sami Karkar, École Centrale de Lyon, France

Recent studies have focused on developing metamaterials for acoustic applications, inspired by electromagnetic 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.
17:30 - 17:45
Nonlinear Optics in Silicon Hybrid Gap Plasmon Waveguides
- Michael P. Nielsen, Imperial College London, United Kingdom
- Lucas Lafene, Imperial College London, United Kingdom
- Aliaksaandra Rakovich, Imperial College London, United Kingdom
- Thomas Strkos & H. Sidiroglou, 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 167±26 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 (CHDHS)
- Jungik 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 CHDHS, a metamaterial capable of broadband absorption through a simple structure.

Liquid-Filled Double-Porosity Granular Media: A Novel Class of Phononic Crystals
- Athina Alievziki, Normandie Univ, UHAVRE, Laboratoire Ondes et Milieux Complexes, UMR CNRS 6294, France
- Rebeca Saindigu, Normandie Univ, UHAVRE, Laboratoire Ondes et Milieux Complexes, UMR CNRS 6294, France
- Pascal Rembert, Normandie Univ, UHAVRE, Laboratoire Ondes et Milieux Complexes, UMR CNRS 6294, France
- Bruno Morvan, Normandie Univ, UHAVRE, 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 - 18:45
Study of graded index metamaterials: transparency and control of electromagnetic waves
- Benjamin Visa, 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.

19:00 - 20:00
Round Table Discussion moderated by Lina Persachini, Maria Maragkou and Rachel Won.

17:45 - 18:00
Interplay of Magnetic and Electric Nonlinear Responses in AlGaAs Nanopillars
- Sergey Knok, Australian National University, Australia
- Lei Xu, Australian National University, Australia
- Rocio Camacho-Morales, Australian National University, Australia
- Hussain Rahmani, Australian National University, Australia
- Lei Wang, Australian National University, Australia
- Darja Simnova, Australian National University, Australia
- Guoquan Zhang, Australian National University, Australia
- Hark Hoo Tan, Australian National University, Australia
- Chemnupalli Jagadish, Australian National University, Australia
- Yury Khvostchuk, Australian National University, Australia
- Dragomir Neshev, Australian National University, Australia

We suggest and demonstrate experimentally efficient second-harmonic generation with AlGaAs nanopillars. We show that the harmonic directionality and efficiency are defined by interplay of electric and magnetic multipole and controlled by incident polarization of light.

18:00 - 18:45
Experimental 3D Illusion for Magnetic Fields
- Rosa Mach-Ballarin, Universitat Autonoma de Barcelona, Spain
- Albert Para, 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.

18:45 - 20:00
Study of graded index metamaterials: transparency and control of electromagnetic waves
- Benjamin Visa, 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.

19:00 - 20:00
Round Table Discussion moderated by Lina Persachini, Maria Maragkou and Rachel Won.
### Metamaterials 2017 Program

**Wednesday, 30th August**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00 - 10:00</td>
<td><strong>PLENARY SESSION III</strong></td>
</tr>
<tr>
<td>09:00</td>
<td>Plasmonic Metamaterials 2.0: from Nanophotonics to Energy Applications</td>
</tr>
<tr>
<td>09:00 - 10:00</td>
<td>Session chairperson: Sergei Tretyakov</td>
</tr>
<tr>
<td>09:00 - 10:00</td>
<td>Vladimir M. Shalaev, School of Electrical &amp; Computer Engineering and Birck Nanotechnology Center, Purdue University, USA</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>COFFEE BREAK (WEDNESDAY MORNING)</td>
</tr>
<tr>
<td>10:30 - 12:30</td>
<td><strong>ORAL SESSIONS (WEDNESDAY MORNING)</strong></td>
</tr>
<tr>
<td>10:30</td>
<td>SPECIAL SESSION ON MECHANICAL METAMATERIALS</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Organizer: Muamer Kadic</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Session chairperson: Muamer Kadic</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Parity-Time Synthetic Phononic Media</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Johan Christensen, UC3M, Spain</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Suppression of Fluorescence Quenching and Strong-Coupling in Plasmonic Nanocavities</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Nuttapol Kongsuman, Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Angela Demetriladou, Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Rohit Chikkaraddi, Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>QUANTUM PLASMONICS AND SUPERCONDUCTING METAMATERIALS</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>Session chairperson: Stefan Rotter</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>Parity-Time Synthetic Phononic Media</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>• Johan Christensen, UC3M, Spain</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>Suppression of Fluorescence Quenching and Strong-Coupling in Plasmonic Nanocavities</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>• Nuttapol Kongsuman, Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>• Angela Demetriladou, Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>• Rohit Chikkaraddi, Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom</td>
</tr>
<tr>
<td>10:30 - 12:30</td>
<td>METASURFACES II</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Session chairpersons: Christophe Caloz, Filippo Capolino</td>
</tr>
<tr>
<td>10:30 - 12:30</td>
<td>Optical Metasurfaces to Bring Computer Graphics Tricks to Real Optical Systems</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Alexander Minovich, King’s College London, United Kingdom</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Manuel Peter, Rheinische Friedrich-Wilhelms-University Bonn, Germany</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Felix Blackmann, Rheinische Friedrich-Wilhelms-University Bonn, Germany</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Manuel Becker, Rheinische Friedrich-Wilhelms-University Bonn, Germany</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Stefan Linden, Rheinische Friedrich-Wilhelms-University Bonn, Germany</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>TUNABLE, RECONFIGURABLE AND NONLINEAR METAMATERIALS</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Session chairperson: Pavel Belov</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Integration of metamaterials with optical fiber technologies</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Nikolay Zheludev, University of Southampton, UK and NTU, Singapore, United Kingdom &amp; Singapore</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Eric Plum, University of Southampton, United Kingdom</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>• Kevin MacDonald, University of Southampton, United Kingdom</td>
</tr>
</tbody>
</table>

The fields of nanophotonics, plasmonics and optical metamaterials have enabled unprecedented ways to control the flow of 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.
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.

- Muamer Kadic, Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom
- Jingyuan Qu, Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK, United Kingdom
- Martin Wegener, Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany
- 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 close 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.

• Ortwin Hess, Blackett Laboratory, Prince Consort Road, Imperial College London, London SW7 2AZ, UK, United Kingdom

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 (PMAC), 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

Multi-Channel Reflectors: Versatile Performance Experimentally Tested

- Svetlana Tcvetkova, Aalto University, Finland
- Viktor Asadchy, Aalto University, Finland
- Ana Díaz-Rubio, Aalto University, Finland
- Do-Hoon Kwon, Aalto University, Finland
- Sangal Tsytyakov, 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, build, and test new multi-channel reflectors.

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. Nielsen, Imperial College London, United Kingdom
- Rupert F. Oulton, Imperial College London, United Kingdom
- Stefan A. Maier, Imperial College London, United Kingdom
11:30 - 11:45
Rational design of reconfigurable prismatic architected materials
- Johannes Overvelde, AMOLF, Netherlands
- James W. Weaver, Harvard, United States
- Chuck Hoberman, Harvard, United States
- Katia Bertoldi, Harvard, United States

Inspirited 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: A video preview can be watched through this link, see also recently published article in Nature.

Towards Ultrastrouchn Viclriciting Coupling by Dynamical Molecular Aggregation
- Francoco 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 Blanco, CNR Nanotec, Italy
- Lorenzo Dominici, CNR Nanotec, Italy
- Dario Ballarini, CNR Nanotec, Italy
- Valentina Arlina, 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 ultrastrouchn coupling regime.

11:45 - 12:00
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, rerouting, rainbow trapping and mode conversion.

Transformations to obtain analytical expressions for the spectral density evaluated in the surrounding 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
Dielectric Rod Metasurfaces: Exploiting Toroidal and Magnetic Dipole Resonances
- Odysseas Tulpakov, Foundation for Research and Technology Hellas, Greece
- Anna Tsalamprou, 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.

Fabricate, and experimentally study these new devices, confirming that the performance is nearly perfect. Media link: See arxiv preprint

11:15 - 11:30
Non-Local Metasurfaces for Perfect Control of Reflection and Transmission
- Sergei Tretyakov, Aalto University, Finland
- Ana Diaz-Rubio, Aalto University, Finland
- Viktar Asadych, 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 deflecting 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 strong spatial nonlinear effects in anisotropic non-local metasurfaces.

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 Salah, Centre Commun de Ressources in Microondes CCDN, 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 Geoffrin, 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.
**Wednesday 12:00 - 12:15**  
**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 gyroscopes.

**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 nanoparticles 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.

**2:00 - 2:15**  
**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.

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:45 - 12:00</td>
<td>Unidirectional Wave Propagation in Chiral Elastic Lattices</td>
</tr>
<tr>
<td></td>
<td>• Giorgio Carta, Liverpool John Moores University, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>• Ian Jones, Liverpool John Moores University, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>• Natasha Movchan, University of Liverpool, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>• Alexander Movchan, University of Liverpool, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>• Michael Nieves, Liverpool John Moores University, United Kingdom</td>
</tr>
<tr>
<td>12:00 - 12:15</td>
<td>Quantum Dynamics of an Interacting Electron Gas in a Metal Nanosphere</td>
</tr>
<tr>
<td></td>
<td>• Alexandra Crai, Imperial College London, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>• Andreas Pusch, Imperial College London, United Kingdom</td>
</tr>
<tr>
<td></td>
<td>• Doris E. Reiter, University of Münster, Germany</td>
</tr>
<tr>
<td></td>
<td>• Benjamin A. Burnett, NG Next, Northrop Grumman Corporation, USA</td>
</tr>
<tr>
<td></td>
<td>• Tilmann Kuhn, University of Münster, Germany</td>
</tr>
<tr>
<td></td>
<td>• Ortwin Hess, Imperial College London, United Kingdom</td>
</tr>
<tr>
<td>12:00 - 12:15</td>
<td>Plasmonic nanostructures provide pathways for light</td>
</tr>
<tr>
<td></td>
<td>to generate hot electrons or manipulate chemical reactions on the</td>
</tr>
<tr>
<td></td>
<td>nanoscale. However, when the size of the nanoparticles becomes</td>
</tr>
<tr>
<td></td>
<td>smaller and smaller it is questionable whether a classical theory</td>
</tr>
<tr>
<td></td>
<td>describes the microscopic behaviour of the electronic system</td>
</tr>
<tr>
<td></td>
<td>adequately. Here, we study the optically generated many-particle</td>
</tr>
<tr>
<td></td>
<td>dynamics using the density matrix formalism providing a quantum</td>
</tr>
<tr>
<td></td>
<td>picture of the optical response of a metal nanosphere. The resulting</td>
</tr>
<tr>
<td></td>
<td>dielectric susceptibility spectra show discrete resonances resulting</td>
</tr>
<tr>
<td></td>
<td>from a collective response mediated by the Coulomb interaction between</td>
</tr>
<tr>
<td></td>
<td>the electrons.</td>
</tr>
</tbody>
</table>

---

**Wednesday 12:00 - 12:15**  
**Quantum optics of zero-index media**  
- Ilídio Liberal, Public University of Navarra, Spain  
- Nadir Englebier, University of Pennsylvania, United States  
  
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 4-port epsilon-mu-near-zero (EMNZ) hub can be utilized in the generation of subradiant, maximally entangled, multi-qubit states.

---

**12:00 - 12:15**  
**Invited Oral**  
- Vincenzo Galbi, 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.
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, NTU, 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, Nanyang Technological University, Singapore
Giorgio Adamo, Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore
Harish N. S. Krishnamoorthy, Centre for Disruptive Photonic Technologies, SPMS, NTU, Singapore
Amalita Bruno, Energy Research Institute @ NTU (ERI@N), Nanyang Technological University, Singapore
Daniele Cortecchia, Interdisciplinary Graduate School, Nanyang Technological University, Singapore and Energy Research Institute @ NTU (ERI@N), Nanyang Technological University, Singapore
Mohammad D. Birowosuto, CINTRA UMI CNRS/NTU/THALES 3288, Singapore
Nikolay I. Zheludev, Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore
Cesare Soci, Centre for Disruptive Photonic Technologies, TPI, SPMS, Nanyang Technological University, Singapore

Our measurement of the optical response of unpatterned and nanostructured niobium films show a strong variation around the superconducting transition temperature of 9K and provides the first evidence of link between superconductivity and optical range plasmonics.
### EXOTIC EFFECTS AT MICROWAVES
Session chairperson: Alessio Monti

**14:00 - 14:15**
- Jonathan Gratia, 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.

**14:15 - 14:30**
Strong Variations of Microwave Field Inside Opal-Based Artificial Crystals
- Anatoly Binkovich, 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
- 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 of electromagnetic mode profile sculpting in wire media.

### OPTICAL METAMATERIALS
Session chairperson: Richard Ziolkowski

**14:00 - 14:15**
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**
Resonant Dielectric Particles with Refractive Index Less Than Two
*Invited oral:*
- Boris Lukyanchuk, 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 effects which are not induced by dielectric materials. Our starting point is the familiar Lorentz force law and we exploit symmetries and mechanical properties of photons propagating through such media.

**14:30 - 14:45**
Quasistatic Metamaterials: Magnetic Coupling Enhancement by Effective Space Cancellation
- Jordi Pest-Camps, Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences / Institute for Theoretical Physics, University of Innsbruck, Austria
- Carlos Navau, Departament de Física, Universitat Autònoma de Barcelona, Spain
- Alvaro Sanchez, Departament de Física, Universitat Autònoma de Barcelona, Spain

Metamaterials and transformation optics have

### OPTICAL FORCES
Session chairperson: Richard Ziolkowski

**14:00 - 14:15**
Conformal Talbot Effect
- Hal Liu, Nanjing University, China

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.

**14:15 - 14:30**
Curvature and Transformations
- Paul Kinsler, Lancaster University, United Kingdom
- Jonathan Gratia, Lancaster University, United Kingdom
- Martin McColl, 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**
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 magnetodielectric 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.

### OPTICAL METAMATERIALS
Session chairperson: Ross McPhedran

**14:00 - 14:15**
Transformation Electromagnetics
*Session chairperson: Ross McPhedran*

**14:15 - 14:30**
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 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**
Quasistatic Metamaterials: Magnetic Coupling Enhancement by Effective Space Cancellation
- Jordi Pest-Camps, Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences / Institute for Theoretical Physics, University of Innsbruck, Austria
- Carlos Navau, Departament de Física, Universitat Autònoma de Barcelona, Spain
- Alvaro Sanchez, Departament de Física, Universitat Autònoma de Barcelona, Spain

Metamaterials and transformation optics have
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 averaged sense per length of wire medium. It enables the exact analytical solution of Maxwell's equations for spherical particles (so called Mie theory). We also discuss some other particle geometries (spherical, 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

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

Invited oral:
- Stefan Rottner, 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”.

15:00 - 15:15

Broadband Suppression of Backscattering at Optical Frequencies

- Mohamed Ismail Abdelsalhman, 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”.

15:15 - 15:30

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, then, subsequently, we present reflective properties of discontinuously transformed media as a function of the coordinate stretching.

15:30 - 15:45

Metamaterial-Based Bessel Beam Launcher

- Nikolas Chiotellis, University of Michigan, USA
- Anthony Grbic, University of Michigan, USA
- Carsten Rockstuhl, Karlsruhe Institute of Technology, Germany
- Mohammed Ismail Abdelsalhman, Karlsruhe Institute of Technology, Germany
- Philippe Tassin, Chalmers University, Sweden
- Igor Nefedov, Aalto University, Finland
- Alexander Shalin, Nano_optomechanics Laboratory, ITMO University, St. Petersburg, Russia

We present a general way to optimize electromagnetic beams for light-matter interactions. Given an object and a desired function like exerting 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 upper bound.

15:45 - 16:00

All-Purpose Beam Optimization

- Mohamed Ismail Abdelsalhman, Karlsruhe Institute of Technology, Germany
- Ivan Fernandez-Corbaton, Karlsruhe Institute of Technology, Germany
- Carsten Rockstuhl, Karlsruhe Institute of Technology, Germany
- Mohammed Ismail Abdelsalhman, Karlsruhe Institute of Technology, Germany
- Philippe Tassin, Chalmers University, Sweden
- Igor Nefedov, Aalto University, Finland
- Alexander Shalin, Nano_optomechanics 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 pushing force, i.e. directed toward a source of electromagnetic energy flow.
This dispersionless slow wave may be used in signal processing and optical storage applications. The underlying physical mechanism is the compensation effect of power flow in two sides of the waveguide. We study the dispersionless slow wave in waveguides composed of two kinds of single-negative metamaterials.

Institute of Radiophysics and Electronics of National Academy of Ukraine, Ukraine

• Natalya Yashina,
• Hong Chen,
• Zhiwei Guo,

1 - High Gain Metasurface Antenna with Multiple Feeding Structure

• Niamat Hussain, Ajou University, Korea (South)
• Imko 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 x 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 broadband gain of 16.5 dB, 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, OYa. Usikov Institute for Radiophysics and Electronics of National Academy of Sciences of Ukraine, 12, Ak. Proskura st., Kharkiv, 61085, Ukraine

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

• Yuji Silenko, L.N. Gumilyov Eurasian National University, 2, Satpayev st., Astana, 010008, Kazakhstan
• Hanna Sliusarenko, OYa. 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.

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

• Juan Minojosa, Universidad Politecnica de Cartagena, Spain
• Marcello Rossi, Universidad Politecnica de Cartagena, Spain
• Alejandro Alvarez-Melcon, Universidad Politecnica de Cartagena, Spain
• Félix Lorenzo Martínez-Villegas, Universidad Politecnica 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 below 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.
9 - PT symmetry in a quasi-periodic structure with topological edge modes Poster

10 - Fano Resonance Excitations In Slanted Hyperbolic Cavities

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

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

6 - Ferromagnetic Resonance in Fibonacci-modulated Magnetic Metamaterials

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

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

9 - PT symmetry in a quasi-periodic structure with topological edge modes Poster

10 - Fano Resonance Excitations In Slanted Hyperbolic Cavities

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

12 - Modal Analysis of Meta Atoms using a Transfer Matrix Approach
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, Technology Department, Faculty of Life Sciences and Computing, London N7 8DB, UK, UK
- Lutfollah Shafai, Electrical and Computer Engineering, University of Manitoba, Winnipeg, MB, CANADA, CANADA
- Aurora Andújar, Technology Department, Fractus, Barcelona, SPAIN, SPAIN
- Jumae 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 × 16mm². The peak gain and efficiency of the antenna are 15.8dB and -70%.

17 - Low index plasmonics using air-like aerogels

- Changwook Kim, Yonsei University, Korea (South)
- Dongsheok Shin, Yonsei University, Korea (South)
- Seunghwa Baek, Yonsei University, Korea (South)
- Kyounisik 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, Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France
- Fatima Omeir, Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France
- Antoine Moreau, Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France
- Emmanuelle Cantone, Université Clermont Auvergne, CNRS, SIGMA Clermont, Institut Pascal, F-63000 Clermont Ferrand, France, France
- Thierry Tallercio, 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 in U100 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 Garcia-Meca, Valencia Nanophotonics Technology Center (NTC), Spain
- Alejandro Martinez, 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 Metamaterial with Ferrite and Semiconductor Layers

- Illa 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

- JaYuan 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 dB.

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

- Amari Cheriguena, Laboratoire d’Etude des Matériaux (LEM), University of Mohammed Seddik Ben Yahia, Algeria
- Machani Bourdial, Laboratoire d’Etude des Matériaux,University of Mohammed Seddik Ben Yahia, Algeria
- Mahmoud Riad Bergoud, 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 (PWEM). 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 108.

24 - Localized Surface Plasmon Resonance of Magneto-optic Rods

- Yaxian Li, Soochow University, China
- Hua Sun, Soochow University, China

We apply the Ms 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 Derre, Office National d’Etudes et de Recherches Aérospatiales, France
- Frank Simon, Office National d’Etudes et de Recherches Aérospatiales, France

The phase matching and group velocity curves were modeled using the Plane-Wave Expansion method (PWEM). 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 108.

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

- JaYuan 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 dB.

27 - Enhancement Of Second Harmonic Generation In Semiconductors III-V Using One Dimensional Photonic Crystal

- Amari Cheriguena, Laboratoire d’Etude des Matériaux (LEM), University of Mohammed Seddik Ben Yahia, Algeria
- Machani Bourdial, Laboratoire d’Etude des Matériaux,University of Mohammed Seddik Ben Yahia, Algeria
- Mahmoud Riad Bergoud, 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 (PWEM). 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 108.

28 - Localized Surface Plasmon Resonance of Magneto-optic Rods

- Yaxian Li, Soochow University, China
- Hua Sun, Soochow University, China

We apply the Ms 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.

29 - Vibroacoustic Behavior Of A Pre-fractal Distribution In A Sandwich Structure

- Jérémie Derre, Office National d’Etudes et de Recherches Aérospatiales, France
- Frank Simon, Office National d’Etudes et de Recherches Aérospatiales, France

The phase matching and group velocity curves were modeled using the Plane-Wave Expansion method (PWEM). 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 108.
Wednesday

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

• Taavi Replõn, 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 Kosuninov, 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-Batte, 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-Valls, 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 guidelines for future practical implementations of cloaking.

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

• Florian Dubois, Institut des Nanotechnologies de Lyon, France
• Hien 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 Nanostructures 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 wittlk, 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

The optically switchable graphene-based modulators for terahertz frequencies were proposed and investigated. The modulators structure consists of cross-shaped aluminum 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 be used 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 Letticia, 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 Margossian, University of Shahre-Rey, Iran
• Hamed Reza Sheoran, University of Tarbiat-e-Heidari, Iran
• Reza Rezapour, University of Tarbiat-e-Heidari, 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 Dasaifar, Center of Excellence in Electromagnetics, Faculty of Electrical Engineering, K. N. Toosi University of Technology, Iran
• Nourat 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
• Boumbacar 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 nanostuctures for efficient perovskite solar cells

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

The modulator structure consists of cross-shaped aluminum 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 be used in the sensing applications and high-speed communications.
The case of inductive impedance charges connected on the PC is investigated. This configuration enables the 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.

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.

Multiband Compact Frequency Selective Surface Based on Modified Loop and Parasitic Patch

A. Nooross Yeganah, K. N. Toosi University of Technology, Iran

H. Nasrollahi, Imam Khomeini International University, Iran

S. H. Sedighy, Iran University of Science and Tech., Iran

A multiband compact frequency selective surface (FSS) is proposed based on modified square loop parasitic structures 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 tunable structure is designed and simulated to demonstrate the idea which works at 3 GHz, 5.5 GHz and 11 GHz independent from the polarization of incident wave. Moreover the proposed structure has a small size equal to 0.095\times0.095 c\text{\small{2}} where c is the free space wavelength. Flexibility in multiband tuning, simplicity and compact size candidate this FSS a good choice for multiband applications.

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

M. Sharifian Mazzaei Mollaei, Iran University of Science and Tech., Iran

S. H. Sedighy, Iran University of Science 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, 35.1 GHz and 36.8 GHz. The simulation results verify the proposed idea ability and capability.
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 (SSR) and the proposed closed ring resonator (CRR) both show near perfect antireflection, and the enhanced cross-polarization 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 the 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
- Ivan Steinichev, University of Science and Technology “MISiS”, Russia
- Trevor Benson, University of Nottingham, United Kingdom
- Angela Seddon, University of Nottingham, United Kingdom
- Toshiaki Kitamura, Kansai University, Japan
- Pavel Belov, ITMO University, Russia
- Angela Seddon, University of Nottingham, United Kingdom
- Vlastimil Kopek, Central European Institute of Technology, Brno, Czech Republic
- Martin Hrto, Central European Institute of Technology, Brno, Czech Republic
- Kenichi Matsumoto, Kansai University, Japan

We suggested gated-controlled graphene metadevices where crossed I-type metamaterials and patterned graphene are coupled to modulate polarization elipticity 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.

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

- Soojoong Baek, 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)

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 metamaterials at the microwave frequency range in situ.

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

- Kenichi Matsumoto, Kansai University, Japan
- Ivan Steinichev, University of Science and Technology “MISiS”, Russia
- Polina Kipitanova, ITMO University, Russia
- Toshiaki Kitamura, 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

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

We studied 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

- Andrew Sayanskii, ITMO University, Russia
- Valeri Akimov, Peter the Great St. Petersburg Polytechnic University, Russia
- Stanislav Glybovskii, 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

- Anastasia Zalogina, University of information technologies, mechanics and optics, Russia
- Georgiy Zogr, University of information technologies, mechanics and optics, Russia
- Elena Ushakova, University of information technologies, mechanics and optics, Russia
- Filipp Komissarev, University of information technologies, mechanics and optics, Russia
- St. Petersburg Academic University, Russia

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 Pucko, 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 Anderson 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 velocity and refraction angle of light.

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
- Irla Sedova, Vladimir State University named after A.G. and N.G. Stoletovs, Russia
- Evgenia 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 properties 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 Metamfilm 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 metamfilm. We demonstrate that, if the absorption coefficient at particular wavelength is small enough (but not negligible), then silica glass metamfilm can be replaced by an equivalent thin film. The absorption is not small this replacement is not possible.

61 - Quantitative 3D Imaging of Metasurfaces Phase Response

- Jiri Babosky, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Aneta K. Dová, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Lenka Štěbková, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Lukáš Kajík, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Filip Ligejman, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Martin Hro, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Petr Dvořák, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Mat J. Ty, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Jana olifiková, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Vlastimil K. Ápek, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Raděk Kalouský, Central European Institute of Technology, Brno University of Technology, Czech Republic
- Tomáš Šikola, Central European 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

- Jeong Weon Wu, Ewha Womans University, Korea (South)
- 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 Ja, Ewha Womans University, Korea (South)
- Dong Ho Kim, Youngnam University, Korea (South)

Translational 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 CHM 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 University, Russia
- Dmitriy Dobrykh, ITMO University, Russia
- Stanislav Glybovskii, ITMO University, Russia
- Irina Melchikova, ITMO University, Russia
- Pavel Belov, ITMO University, Russia
- Yeungnam University, Korea (South)
In this work we propose and study via numerical simulation a new metamaterial-inspired 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

- Serey Vovak, Skolkovo Institute of Science and Technology, Russia
- Denis Zhigunov, Moscow State University, Russia
- Olga Shalygina, Moscow State University, Russia
- Alexander Marinins, KTH Royal Institute of Technology, Sweden
- Polina Vablischchevich, 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 photoluminescence spectra are in agreement with experimental results.

65 - Analytical Model for Rotational and Anisotropic Metasolids

- Ellie Pavier, Laboratoire Modélisation et Simulation Multi Echelle, Université Paris-Est, France
- David 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, and with rotational 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, for example, 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 Multifill Carbon-Nanotube

- Rajkumar Jaiswal, Université Catholique de Louvain, Belgium
- Francisco Mederos Henry, Université Catholique de Louvain, Belgium
- Verdi Dupont, Belgian Ceramic Research Centre, Belgium
- Sophie Hermans, Université Catholique de Louvain, Belgium
- Arnaud Delcorte, Université Catholique de Louvain, Belgium
- Christian Bailly, Université Catholique de Louvain, Belgium
- Cathy Delmotte, Belgian Ceramic Research Centre, Belgium
- Véronique Lardot, Belgian Ceramic Research Centre, Belgium
- Jean-Pierre Raskin, Université Catholique de Louvain, Belgium
- Isabelle Hueyns, Université Catholique de Louvain, Belgium

In this paper, we present a ultra-wideband radar absorbing structure operating in 5-900GHz frequency range. Two layer of Frequency Selective Surfaces (FSS) separated by dielectric spacer and having 160 fl/sq. and 80 fl/sq. respectively are printed on flexible PC-sheet with home-made water-based MWCNT-ink. For a thickness of 5nm a measured reflection coefficient bandwidth below -15dB is achieved over a bandwidth of 33GHz between 400GHz and 730GHz, and agrees very well with simulation. The higher absorption bandwidth of about 15% at normal incidence is benefitted from the stacked gradient of optimized surface resistance of resistive-FSS structure separated by below 0.4 spacer besides the bandwidth of the proposed absorber combines flexibly 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 Ness, Department of Physics, NTNU Norway, Norway
- Thomas Brakstad, Department of Physics, NTNU Norway, Norway
- Per Magnus Wollman, Department of Physics, NTNU Norway, Norway
- Morten Kildemo, Department of Physics, NTNU Norway, Norway
- Inge 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 - Ultra-high-Q Surface Plasmon Polariton Modes in Magnetic Multilayered Structures with Garnet for Sensing Applications

- Daría Ignatyeva, Lomonosov Moscow State University, Russia
- Pavel Kaplanov, Russian Quantum Center, Russia
- Grigory Knyazev, Lomonosov Moscow State University, Russia
- Sergei Sakatski, École Polytechnique Fédérale de Lausanne, Switzerland
- Mohammad Nej-E-Alam, Edith Cowan University, Australia
- Mikhail Vasiliev, 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 Electronics (VNIIE), Russia
- Vasily Klimov, Dukhov Research Institute of Electronics (VNIIE), Russia

We numerically investigated the influence of the spatial distribution of the nanoholes 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, KIT University, India
- Bajra Paranj Mishra, KIT 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 fed slot in the frequency range of 4.6-7.4 GHz. The permittivity (ε), permeability (µ) and refractive index (n) 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 (HFFS). 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, KIT University, India
- Bajra Paranj Mishra, KIT University, India

In this work, we propose and study via numerical simulation a new metamaterial-inspired 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.
In this communication, a hybrid metallic split ring resonator (SSR) 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 re-emitted 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 (NZTMM) lens antenna to increase the focusing effect. Metamaterial lens aperture size is of 1000μm x 1500μm x 2500μm.

72 - Probing the dynamics of microwave pulses in 1D disordered waveguides
- David Petteau, Bar-Ilan University, Israel
- Azriel Genack, Queen's 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 $\varepsilon_A$ or $\varepsilon_B$. Randomness is either introduced by randomly juxtaposing slabs $\varepsilon_A$ or $\varepsilon_B$ in a binomial 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 Lamaitre, Université Clermont Auvergne, France
- Kofi Edes, 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 relected 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'Argostino, Center for Biomolecular Nanotechnologies of IIT@UniLe, Lecce, Italy
- Fabio Della Sala, Università di Roma Tor Vergata, Rome, Italy

Electronic dynamics methods have been proved to be useful and powerful tools to study localized and delocalized surface plasmons. Anyway the recent progresses achieved in fabrication techniques to control sub-nanometer structures and features has lead to more rigorous approaches able to theoretically describe nonlinearity or the split-off 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 (DFT) 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 propose 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 Ag clusters and report on our best results for handtuned on-site energies. With the proposed parameterization 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
- Yvonnes Achacou, 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 arrangement, which emerges 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 bandgap tunability purposes.

76 - Sensors based on 2D waveguide with metallic coating
- Alexander V. Dorofeenko, Dukhov Research Institute of Automatics, Russia
- Igor A. Nechepepurenko, Dukhov Research Institute of Automatics, Russia
- Alexander Z. Zabavsky, Dukhov Research Institute of Automatics, Russia
- Eugene S. Andrianov, Dukhov Research Institute of Automatics, Russia
- Alexander A. Pukhov, Dukhov Research Institute of Automatics, Russia
- Alexey P. Virogradov, Dukhov Research Institute of Automatics, Russia
- Yuri E. Lopovik, 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 dropping 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)
- Soohee Jeon, Korea Institute of Machinery & Materials, Korea (South)
- Jae Ryoon 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, plasma-chemical etching process 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 reflective 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 phenomenon on the semiconducting ZnO nanograting structure were directly observed by means of confocal microscopy-based scanning photocurrent microscopy (SPCM). The metallic grating has a high spatial resolution distinguishing the 200 nm width of the ZnO nanostripe. Through diverse periods of nanograting, in 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 Gallifi, 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
- Guan Wang, Tongji University, China
- Yewen Zhang, Tongji University, China
- Yunshi Li, Tongji University, China
An anisotropic subwavelength planar metamaterial is presented at low frequencies, composed of periodically arranged lumped components and subwavelength distributed structures with the combination of double layer rectangular spiral unit structure. The magnetic polarization induces the resonance of the dual-layer metamaterial excited by an alternating electromagnetic field. The equivalent value of the magnetic polarization in the metamaterial is obtained within integral treatment of the magnetic polarization distribution.

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

- Ilya Zakharov, VNIA, Russia
- Bjorn Maas, University of Mons, Belgium

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

- Galad Alattes Menendez, University of Mons, Belgium
- Mohammadreza F. Imani, Duke University, United States

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.

ORAL SESSIONS (WEDNESDAY - AFTERNOON 2)

17:30 - 18:30
THEORY AND MODELLING II

Session chairperson: Stefano Maci

- Laura Pulido Manera, 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 metasurfaces and antennas for numerous applications such as beam-forming arrays, holograms, and flat lenses among others. In this technique, a metamaterial is described as a collection of dipoles (meta-atoms) characterized by their polarizability. The utility of this technique relies on a 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 metamaterials. We demonstrate that the extracted polarizability changes depending on the surrounding settings, highlighting the importance of proper characterization of meta-atoms in different environments.

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

- Aurea Larre, 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

Multisdielectric 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
- Sebadien Guennreau, 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.

DEVICE APPLICATIONS I

Session chairperson: Tiago Morgado

- 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 nonmetallic 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

Session chairperson: Maxim Gorkunov

- Miguel Beruete, Universidad Pública de Navarra, Spain

Terahertz devices 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 to terahertz (THz) technology achieved in the Antennas Group – Terab 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.
In this paper, we apply a reformulated version of the Surface Admittance 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 admittance cloak, as originally introduced for Manto Cloaking, is computed in a closed-form solution at any frequency regime (quasi-static and beyond).

Superdirectivity for Coupled Dimers of Meta-Atoms at MHz

Pavel Petrov, M.V.Lomonosov Moscow State University, Faculty of Physics, Magnetism Department, Russia

Anna Rudovskaya, M.V.Lomonosov Moscow State University, Faculty of Physics, Magnetism Department, Russia

Christopher Stevens, University of Oxford, Department of Engineering Science, UK

Ekaterina Shamoolina, 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. Superdirectivity and the 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 superdirectivity configurations of dimers of meta-atoms of various shape, resonant characteristics and separation. This study paves the way for further work on superdirective metamaterial meta-surfaces.

Reflective Photonic Limiter for the W-band

Rodion Chulov, University of Texas at San Antonio, USA

Andrey Chabanov, University of Texas at San Antonio, USA

Boney Thomas, Wesleyan University, USA

Tsimpikos Kottos, Wesleyan University, USA

Martin Hillard, Air Force Research Laboratory, USA

Banman Jawaid, Air Force Research Laboratory, USA

Terahertz Systems Comprising Rolled-up Metal Microchelics 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

Multiple Scattering Enabled Superdirectivity From a Subwavelength Ensemble Of Resonators

Samuel Metals, Institut Langevin, France

Fabrice Lamont, Institut Langevin, France

Geoffrey Lerosey, Institut Langevin, France

Ensembles of resonators arranged as subwavelength scale, namely, metamaterials, are usually considered for their homogenization properties. It was shown recently that in 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.

Performance Enhancement of Binary Fresnel Lenses Using Metamaterials

Santiago Legaria, Universidad Pública de Navarra, Spain

Víctor 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.
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 multiband 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 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. 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.

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.

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.

Wednesday
• Brad Hoff, Air Force Research Laboratory, USA
• Vladimir Vasilyev, Air Force Research Laboratory, USA
• Nicholas 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.

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.

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.

Wednesday
• Brad Hoff, Air Force Research Laboratory, USA
• Vladimir Vasilyev, Air Force Research Laboratory, USA
• Nicholas 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.

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.

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.

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.

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.
Thursday, 31st August

09:00 - 10:00
PLENARY SESSION IV
Session chairperson: Mario Silveirinha

09:00
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: Sébastien Guenneau; Boris Gralak; Jean-Philippe Groby; Vicente Romero Garcia
Session chairpersons: Sébastien Guenneau; Boris Gralak

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 Pinoccio, University of Messina, Italy
• Ornella Casabianca, University of Messina, Italy
• Giulio Ventura, Politecnico di Torino, Italy
• Francesca Garasaki, University of Messina, Italy
• Bruno Azzurboni, 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

10:30 - 10:45
SPECIAL SESSION ON SEISMIC METAMATERIALS
Organizer: Stéphane Brûlé
Session chairpersons: Stéphane Brûlé; Alexander Movchan

Efficient filtering of seismic waves with seismic metamaterial composed by sub-wavelength local resonator
• Giovanni Pinoccio, University of Messina, Italy
• Ornella Casabianca, University of Messina, Italy
• Giulio Ventura, Politecnico di Torino, Italy
• Francesca Garasaki, University of Messina, Italy
• Bruno Azzurboni, 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

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.
nacks at both extremities (tied two-sided) or open at a single extremity (tied 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 (i) to realize perfect absorption in the latter case.

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.

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 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 (i) to realize perfect absorption in the latter case.

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
- Youssef Achache, Institut EFRETO-ST, Université de Franche-Comté, CNRS, 25044 Besançon Cedex, France, France

Dynamic Homogenization of Acoustic Metamaterials: Additional Constitutive Parameters
- Daniel Torrent, Centre de Recherche Paul Pascal, France
- Marie-Fraise Ponge, Institut de Mécanique et d’Ingénierie, 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.

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-Garcia, 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.

Hierarchical Bio-inspired Dissipative Metamaterials For Low Frequency Attenuation
- Marco Miniaci, Laboratoire Ondes et Milieux Complexes - UMR CNRS 6294, France
- Anastasiia Krushynska, University of Turin - Department of Physics, Italy
- Federico Bosia, University of Turin - Department of Physics, Italy

Enhanced spontaneous emission and nonlinear frequency conversion at exceptional points of inverse-designed photonic crystals
- Zin Lith, Harvard University, USA
- Adi Pick, Harvard University, USA
- Weiliang Jin, Harvard University, USA
- Alejandro Rodriguez, Princeton, USA
- Zin Lith, Harvard University, USA
- Adi Pick, Harvard University, USA
- Weiliang Jin, Harvard University, USA
- Alejandro Rodriguez, Princeton, USA

Slow sound effects: Impedance tube measurement on a 3-D printed sample provides data in good agreement with the theoretical model.

Enhanced spontaneous emission and nonlinear frequency conversion at exceptional points of inverse-designed photonic crystals
- Zin Lith, Harvard University, USA
- Adi Pick, Harvard University, USA
- Weiliang Jin, Harvard University, USA
- Alejandro Rodriguez, Princeton, USA
- Zin Lith, Harvard University, USA
- Adi Pick, Harvard University, USA
- Weiliang Jin, Harvard University, USA
- Alejandro Rodriguez, Princeton, USA
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 materials where these additional constitutive parameters are required for the proper description of acoustic metamaterials. The role of large scale computing behind the development of seismic (and elastic) metamaterials

Olivier Poncelet, Institut de Mécanique et d’Ingénierie, 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.

A paradigm shift has occurred in the past five years on acoustic 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 Mocularity.
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 are possible. 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.

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 understand and analytically predicting Wood’s anomalies, surface modes, and scattering spectra in optical, metallic, and glassy systems. We show, by comparing our theory with computational results, the approach clearly outlines how the diffusive 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.

11:45 - 12:00
Fractal and Spider Web-Inspired Labyrinthine Acoustic Metamaterials
• Anastasija Kruzhynska, Department of Physics, University of Turin, Italy
• Federico Bosia, Department of Physics, University of Turin, Italy
• Marco Minlac, Laboratoire Ondes et Milieux Complessi, 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.

12:00 - 12:15
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
• Edoardo Belloni, Politecnico di Milano, Italy
• Luca Daniel, Massachusetts Institute of Technology, USA
• Raffaele Ardito, Politecnico di Milano, Italy
• Edoardo Belloni, Politecnico di Milano, Italy
• Gabriele D’Alò, Politecnico di Milano, Italy
• Raffaele Ardito, 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 for 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.

12:00 - 12:15
Slow Sound acoustic diode
• Yves Aurégan, LAUM, CNRS, Le Mans Univ., France
• Vassos Achilles, LAUM, CNRS, Le Mans Univ., France
• Vincent Pagneau, 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 occur on a large frequency range that can be extended to very low frequencies.

12:00 - 12:15
Light-Matter Couplings in Evanescent Fields
• Ivan Fernandez-Corbaton, Kaisruhe Institute of Technology, Germany
• Xavier Zambrano-Puyalito, Istituto Italiano di Tecnologia, Genova, Italy
• Nicolas Bonod, Aix Marseille Univ, CNRS, Institut Fresnel, Marseille, France
• Carsten Rockstuhl, Kaisruhe 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/prx/abstract/10.1103/PhysRevX.9.053822

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 atom chain. We have also built 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.
### ORAL SESSIONS (THURSDAY - AFTERNOON 1)

**12:15 - 12:30**

**Homogenization of metamaterials beyond a local response**
- Karim Measri, Karlsruhe Institute for Technology, Germany
- André Khraiboustovskiy, 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 Creome, 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
- Mal Pham Thi, Thales Research Technology, France
- Anne-Christine Hladky-Hennion, IEMN (UMR 8520 CNRS), France

A piezoelectric plate polar 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**

**EXPERIMENTAL TECHNIQUES, FABRICATION AND CHARACTERIZATION OF METAMATERIALS**
- Session chairperson: Xiangdong Zhang

**14:00 - 14:15**

**Spatial Dispersion Effects in Magnetic Metamaterials in Visible Light**
- Daniel Torrent, CNRS - Centre de Recherche Paul Pascal, France
- Sargol Gomez-Graña, CNRS - ICMCB Bordeaux, France
- Vasil Krasnous, University of Manchester, UK
- Alexander Gripenko, University of Manchester, UK
- Alexandre Baron, CNRS - Centre de Recherche Paul Pascal, France
- Virginie Ponsinet, CNRS - Centre de Recherche Paul Pascal, France

**14:00 - 14:15**

**Hyperbolic cavities as tunable platform for spontaneous emission enhancement of dye molecules**
- Maximilian Goetz, Helmholtz-Zentrum Berlin für Materialien und Energie, Germany
- Robert Kloschke, Institute of Physics, AG Theoretical Optics & Photonics, Humboldt-Universität zu Berlin, Germany
- Julia Werra, Institute of Physics, AG Theoretical Optics & Photonics, Humboldt-Universität zu Berlin, Germany

**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.

**12:30 - 14:00**

**LUNCH BREAK (THURSDAY)**

**14:00 - 15:30**

**HYPERBOLIC METAMATERIALS**
- Session chairperson: Evgeniy Narimanov

**14:00 - 14:15**

**Light Trapping in Thin-Film Solar Cells: From Plasmonic To Dielectric Structures**
- Constanttin 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.

**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.
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 $\mu$ 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.

Hyperbolic cavitites from silver / silicon dioxide multilayers are presented as tunable platforms for spontaneous emission enhancement of embedded dye molecules.
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 nanomicro 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.

14:45 - 15:00

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 Novitatsky, Technical University of Denmark, Denmark
- Taaïl 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 hyperspectra —— 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.

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, Technische Universität Berlin, Germany
- Andre de Lustrac, Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, Universités Paris-Saclay, Paris Nanterre, 92410 Ville d’Avray, France, France
- Anastasia Lupu, Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, Université Paris-Saclay, Paris Nanterre, 92410 Ville d’Avray, France, 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.

15:15 - 15:30

Meta-atoms and Metamaterials in Motion

Invited oral:
- Pavel Grinberg, Tel Aviv University, Israel
- Demyt Filonov, Tel Aviv University, Israel
- Vital Kozlov, Tel Aviv University, Israel

Electromagnetic interactions with moving and accelerating bodies inspire 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.
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 Grangé, 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 nanoprint lithography with colloidal suspensions of nonlinear nanoparticles 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. Samual Habib, The University of Sydney, Australia
- Alessio Stefani, The University of Sydney, Australia
- Shaqik Atakaramians, The University of Sydney, Australia
- Simon Fleming, The University of Sydney, Australia
- Boris Kuhlmeier, 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.

Metal-dielectric nanocavity as a versatile optical sensing platform

- Dmitri Zuev, ITMO University, Russia
- Valentina 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 Maskorov, 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.

Chipless RFID Tags Based On Metamaterial Concepts

Invited oral:

- Cristian Herrojo, Universidad Autónoma de Barcelona, Spain
- Javier Mata-Castrejón, Universidad Autónoma de Barcelona, Spain
- Ferran Paredes, Universitat Autònoma de Barcelona, Spain
- Ferran Martin, 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.

Anomalous Surface-Wave Guiding on Omega-Bianisotropic Metasurfaces

- 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 intrinsic manipulation of near-field features, holding potential for wireless power transfer and biomedical imaging applications.

Metal-dielectric nanocavity as a versatile optical sensing platform

- Dmitri Zuev, ITMO University, Russia
- Valentina 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 Maskorov, 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.

Chipless RFID Tags Based On Metamaterial Concepts

Invited oral:

- Cristian Herrojo, Universidad Autónoma de Barcelona, Spain
- Javier Mata-Castrejón, Universidad Autónoma de Barcelona, Spain
- Ferran Paredes, Universitat Autònoma de Barcelona, Spain
- Ferran Martin, 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.

Anomalous Surface-Wave Guiding on Omega-Bianisotropic Metasurfaces

- 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 intrinsic 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, Russia
- 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 M-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 Kikuko conditions are satisfied.
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Presenters</th>
</tr>
</thead>
</table>
| 16:15 - 16:30 | Random metamaterial at high filling factor                                           | • Nicolas Femez, University of Lille, France  
• David Dereudre, University of Lille, France  
• Jianping Hao, University of Lille, France  
• Éric Lheuret, 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 is studied through numerical and experimental investigations. 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 absorbers at THz                                          | • Frédéric Garet, University of Lille, France  
• Christophe Boyaval, 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 μm-size aluminum structures randomly placed onto a kapton dielectric layer with a back-side metal plate. |

| 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  
• Andrew Arzhanilov, Novosibirsk State University, Russia  
• Victor Fedorin, Institute of Semiconductor Physics SB RAS, Russia  

We present the results of extensive theoretical and 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. |

| 16:45 - 17:00 | Non-Bianisotropic Complementary Split Ring Resonators Metasurfaces                   | • Pablo Rodríguez Ulbarri, Universidad Pública de Navarra, Spain  
• Irait Jáuregi, Universidad Pública de Navarra, Spain  
• Miguel Beruete, Universidad Pública de Navarra, Spain  

A modified version of the complementary split ring resonator (CSRR), the non-bianisotropic CSRR (NB-CSRR), is proposed as an angular selective structure, offering opportunities to create light-emitting structures of unprecedented complexity. |

| 16:15 - 16:30 | Electroluminescent Metamaterials                                              | • Guoyu Le-Van, Université Paris-Saclay, Univ. Paris-Sud and CNRS, France  
• Hongyu Wang, Université Paris-Saclay, Univ. Paris-Sud and CNRS, France  
• Xavier Le Roux, Université Paris-Saclay, Univ. Paris-Sud and CNRS, France  
• Abdelhakine Assime, Université Paris-Saclay, Univ. Paris-Sud and CNRS, France  
• Aloysio 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. 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. |

| 16:30 - 16:45 | Optical Metasurfaces for Superposition of Twisted Light Beams                    | • Xianzhong Chen, School of Engineering and Physical Sciences, Heriot-Watt University, United Kingdom  
• Puyong 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. |

| 16:45 - 17:00 | Spectrally Tunable Linear Polarization Rotation Using Stacked Metallic Metamaterials | • Xavier Romahi, FEMTO-ST Institute, France  
• Fadi Baida, FEMTO-ST Institute, France  
• Philippe Boyot, 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 spectrally-polymorphic sensors of a thermal type. Implemented in a three-layered configuration with a capacitively 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 cell sub-wavelengthness 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 metamaterial-based schemes for uncooled thermal subTHz sensing with spectrometric, polychromatic, and imaging capabilities are also considered.

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

Hiba El-Halabi, Beirut Arab University, Lebanon
Hansa Issa, Beirut Arab University, Lebanon
Darine Kaddour, Université Grenoble Alpes, LCIS, France
Souhbi Abou-Chahine, Beirut Arab University, Lebanon
Philippe Ferrari, Université Grenoble Alpes, IMPÉ-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 3:1 dB cut-off frequency of 2.45 GHz is designed realized and measured. Thanks to the slow-wave effect, 4% 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.

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

We report a chiral dielectric metasurface with regular 3D nanorelief patterned by focused ion beam in a 300 nm thick 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 20° 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 metasurfaces and metadevices.
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 in the 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.

17:30 - 18:00
CLOSING CEREMONY

18:00 - 20:00
SOCIAL EVENT

17:15 - 17:30
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-13008, France
- Johann 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

17:15 - 17:30
Angled hole-mask colloidal lithography fabricated plasmonic chiral Au nano-hooks for conformational analysis of proteins
- Gunnar Klöss, 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. These nano-hooks express significant circular dichroism (CD) responses which makes them promising candidates for plasmonically enhanced protein conformation analysis.

17:30 - 18:00
CLOSING CEREMONY

18:00 - 20:00
SOCIAL EVENT
<table>
<thead>
<tr>
<th>Monday, 28th August</th>
<th>Tuesday, 29th August</th>
<th>Wednesday, 30th August</th>
<th>Thursday, 31st August</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>09:00 - 10:00</strong></td>
<td><strong>10:00</strong></td>
<td><strong>10:30 - 12:30</strong></td>
<td><strong>12:30 - 14:00</strong></td>
</tr>
<tr>
<td>Plenary session I</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
</tr>
<tr>
<td><strong>10:30 - 12:30</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>12:30 - 14:00</strong></td>
<td>Lunch Break</td>
<td>Lunch Break</td>
<td>Lunch Break</td>
</tr>
<tr>
<td><strong>15:30 - 16:00</strong></td>
<td>Coffee Break</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
</tr>
<tr>
<td><strong>16:00 - 18:00</strong></td>
<td>Physical Review Journals Symposium</td>
<td>Acoustics I</td>
<td>Topological Effects and Light Spin</td>
</tr>
<tr>
<td><strong>18:00</strong></td>
<td>18:00 : Meet-and-greet the Physical Review Editors followed by Welcome Reception</td>
<td>18:00 - 19:00 Nature Research Symposium : Round Table Discussion</td>
<td>19:30 - 23:30 Gala Dinner</td>
</tr>
</tbody>
</table>