



# **Marina Forum on EMetamaterials**

04 – 05 March 2021, Singapore

[www.marinaforum.org](http://www.marinaforum.org)

## **Technical Program**



## Organizer



## Technical Sponsors



## Financial Sponsors



## Table of Contents

<a href="#"><u>Message from General Chairs .....</u></a>	<a href="#"><u>4</u></a>
<a href="#"><u>Organizing Committee.....</u></a>	<a href="#"><u>6</u></a>
<a href="#"><u>Technical Program Committee.....</u></a>	<a href="#"><u>6</u></a>
<a href="#"><u>Award Committee .....</u></a>	<a href="#"><u>7</u></a>
<a href="#"><u><b>Zoom Link for the Forum .....</b></u></a>	<a href="#"><u>8</u></a>
<a href="#"><u>Technical Program Overview.....</u></a>	<a href="#"><u>9</u></a>
<a href="#"><u>Technical Program Details.....</u></a>	<a href="#"><u>10</u></a>
<a href="#"><u><i>(SPC Session Details, Page 19-20)</i></u></a>	

## Message from General Chairs

On behalf of the Organizing Committee, we warmly welcome you to the inaugural Marina Forum (MarFo in short) on EMetamaterials 2021 in Singapore!

The name of the forum is coined after Marina Bay, a landscape of Singapore, an artificial bay. The concept of Marina Bay stemmed from the world-renowned architect, Chinese-American Ieoh Ming Pei and completed by Italian Moshe Safdie. I. M. Pei is best known for his work of the iconic glass pyramid in the courtyard of the Louvre Museum in Paris.

We hope this new forum will nurture fresh creation and innovation in the fields of information and electronics. The forum will provide a new type of international platform to demonstrate the latest progress in selected multitude and inter-disciplinary topics of research and technology. We will invite the world's top and active researchers to share their new findings, innovative technologies, and successful applications in new research directions. Furthermore, we will offer opportunities for next generation researchers to demonstrate their research work.

We start the Marina Forum series with the main focus on EMetamaterials. Electromagnetic (EM) metamaterials have long been an exciting topic in both EM physics and engineering societies. In particular, since Sir John Pendry published his pioneering work in the realization of negative permittivity and permeability in the late 1990s, we have witnessed a revolutionary progress in research, development, and applications of EM metamaterials. By 28 February 2021, Google Search shows 4,250,000 items in just 0.5 second by using "metamaterials" as the keyword, which even outshines "AI".

This inaugural online international forum will offer a rich scientific program contributed by six renowned keynote and six invited speakers from Asia, Europe, and North America. They will elucidate their theoretical findings as well as innovative engineering technologies ranging from microwave to optical regimes. Their talks will update us on the latest progress in the R&D of metamaterials, metasurfaces, and metalines based EM devices and their applications.

The Student Paper Contest, as an integral part of the program, is organized to showcase students' excellent research works and offer opportunities for them to interact with senior researchers. Twelve out of forty-one submissions have been shortlisted for final presentation on the first day of the Forum.

The MarFo is organized by IEEE RFID Singapore Chapter and technically sponsored by IEEE, IEEE MTT/AP and EMC Singapore chapters, Advanced Research and Technology Innovation Center of National University of Singapore, AIM Asia, World Scientific, Laxcen, and Opto-Electronics Advances. Our special thanks go to Huawei Technologies, Dassault Systemés, Sinolink, Nano Dimension, InnoWave, and Spring Technologies for their strong financial support!

We look forward to “meeting” all of you — our speakers, sponsors, and participants virtually. We also optimistically hope to host you physically in Marina Bay, Singapore at the next Marina Forum soon!

**Prof. Zhi Ning CHEN**

*General Chair*

*National University of Singapore*

**Dr. Xianming QING**

*General Co-Chair*

*Institute for Infocomm Research*

## Organizing Committee



**Prof. Zhi Ning CHEN**

*General Chair*

*National University of Singapore*



**Dr. Xianming QING**

*General Co-Chair*

*Institute for Infocomm Research*



**Dr. Wei LIU**

*Technical Program & Logistics Co-Chair*

*National University of Singapore*



**Dr. En-Xiao LIU**

*Finance & Technical Program Co-Chair*

*Institute of High Performance Computing*



**Dr. Terence Shie Ping SEE**

*Logistics Co-Chair / Finance Co-Chair*

*Institute for Infocomm Research*

## Technical Program Committee

**Enxiao Liu**, *Institute of High Performance Computing, Singapore (co-Chair)*

**Wei Liu**, *National University of Singapore, Singapore (co-Chair)*

**Harry Atwater**, *California Institute of Technology, USA*

**Liang Feng**, *University of Pennsylvania, USA*

**Minghui Hong**, *National University of Singapore, Singapore*

**Zhi Hao Jiang**, *Southeast University, China*

**Pui Yi Lau**, *Laxcen Technology Limited (Hong Kong), China*

**Cheng-Wei Qiu**, *National University of Singapore, Singapore*

**Weihong Xiao**, *Huawei Technologies Co., Ltd., China*

**Fan Yang**, *Tsinghua University, China*

**Tao Yuan**, *Kunshan Innowave Communication Technologies, China*

**Anatoly Zayats**, *King's College London, UK*

## Award Committee

**Hisamatsu Nakano**, *Hosei University, Japan (co-Chair)*

**Anatoly Zayats**, *King's College London, UK (co-Chair)*

**Minghui Hong**, *National University of Singapore, Singapore*

**Zhi Hao Jiang**, *Southeast University, China*

## Zoom Link for the Forum

*(One Link for Two Days)*

**Marina Forum on EMetamaterials 2021**

**04 -05 March 2021, Singapore**



**Join Zoom Meeting**

**Meeting ID: 843 8521 2054**

**Passcode: 040503**

### Zoom Link

<https://us02web.zoom.us/j/84385212054?pwd=MmFnYTZvTGJpWnc3bTVtc1diRjFYQT09>

One tap mobile

+12532158782,,84385212054#,,,,\*040503# US (Tacoma)

+13017158592,,84385212054#,,,,\*040503# US (Washington DC)

Dial from your location

+1 253 215 8782 US (Tacoma)

+1 301 715 8592 US (Washington DC)

+1 312 626 6799 US (Chicago)

+1 346 248 7799 US (Houston)

+1 669 900 6833 US (San Jose)

+1 929 436 2866 US (New York)

Meeting ID: 843 8521 2054

Passcode: 040503

Find your local number: <https://us02web.zoom.us/j/84385212054?pwd=MmFnYTZvTGJpWnc3bTVtc1diRjFYQT09>



# Marina Forum on EMetamaterials 2021

## Technical Program Overview

SN	Singapore Time [ GMT+8]	04 March (Thu)	05 March (Fri)
AM-O	8:40 AM - 9:00 AM	<b>Opening Ceremony</b>	
		<b>Session Chairs:</b> Chengwei Qiu and En-Xiao Liu	<b>Session Chairs:</b> Fan Yang and Terence See
AM-1	9:00 AM - 10:00 AM	[KEYNOTE] Four-Dimensional (4D) Metamaterials for Structuring Fields and Waves <b>NADER ENGHETA</b> , University of Pennsylvania, USA	[KEYNOTE] Huygens' Metasurfaces for Antenna Beamforming and Beamsteering <b>GEORGE ELEFTHERIADES</b> , University of Toronto, Canada
AM-2	10:00 AM - 10:40 AM	[INVITED] Electronically Reconfigurable Metasurfaces for Active Wavefront Control in Ranging and Communications <b>HARRY ATWATER</b> , California Institute of Technology, USA	[INVITED] Symmetry Driven Photonics for New Active Functionality On-Chip <b>LIANG FENG</b> , University of Pennsylvania, USA
	10:40 AM - 10:50 AM	Session Break	Session Break
AM-3	10:50 AM - 11:30 AM	[INVITED] Metasurfaces for Vortex Generation, Multiplexing and Laser <b>CHENGWEI QIU</b> , National University of Singapore, Singapore	[INVITED] The Fundamentals and Frontiers of Surface Electromagnetics <b>FAN YANG</b> , Tsinghua University, China
AM-4	11:30 AM - 12:30 PM	[KEYNOTE] Recent Progress in Circularly Polarized Metamaterial Antennas <b>HISAMATSU NAKANO</b> , Hosei University, Japan	[KEYNOTE] Information Metasurfaces and Intelligent Metasurfaces <b>TIE JUN CUI</b> , Southeast University, China
<b>Lunch</b>	12:30 PM - 2:30 PM	Lunch Break	<b>SPC Award Ceremony &amp; Lunch Break</b>
		<b>Session Chairs:</b> Hisamatsu Nakano and Wei Liu	<b>Session Chairs:</b> Minghui Hong and Xianming Qing
PM-1	2:30 PM - 3:30 PM	<b>Student Paper Contest (SPC) Presentation Session I -- Application Paper Track</b>	[KEYNOTE] Metasurfaces for Shaping Reflected and Scattered Waves <b>SERGEI TRETYAKOV</b> , Aalto University, Finland
PM-2	3:30 PM - 4:10 PM		[INVITED] Latest Advances in Magnetless Nonreciprocal Metasurfaces <b>CHRISTOPHE CALOZ</b> , ESAT-WAVECORE-META, Belgium
	4:10 PM - 4:20 PM	Session Break	Session Break
PM-3	4:20 PM - 5:00 PM	<b>Student Paper Contest (SPC) Presentation Session II-- Theory Paper Track</b>	[INVITED] Hyperbolic Metamaterials for Waveguiding and Polarization Control <b>ANATOLY ZAYATS</b> , King's College London, UK
PM-4	5:00 PM - 6:00 PM		[KEYNOTE] Metamaterials that Travel Faster than Light <b>JOHN PENDRY</b> , Imperial College, UK

# **Technical Program**

[Keynote] 9:00 AM - 10:00 AM, 04 March (Thu)

## **Four-Dimensional (4D) Metamaterials for Structuring Fields and Waves**

NADER ENGHETA, *University of Pennsylvania, USA*

Materials are often used to tailor, control and manipulate electromagnetic fields and waves. Metamaterials have provided exciting possibilities in extreme functionality in sculpting and structuring wave-matter interaction. We have been exploring how four-dimensional metamaterials, i.e., the materials in which the material parameters can change rapidly with time in addition to (or instead of) change with space, can give us new platforms in structuring fields and waves that lead to certain useful functions. Several research programs are being investigated in my group. As one program, we have been developing material platforms that can perform analog computation, such as solving integral and differential equations and inverting matrices with waves, as waves interact with them. Such “metamaterial machines” operate as wave-based analog computing machines, with possible expansion into micro- and nanoscale domains. Another scenario deals with spatiotemporal metamaterials, in which temporal variation of material parameters is added to the tools of spatial inhomogeneities for manipulating light-matter interaction. These 4D structures can also be used for manipulation of diffusion to achieve asymmetric diffusion and trapping and for developing the concept temporal slab lens. The third category of structured waves is achieved in the near-zero-index materials and associated photonic doping that exhibit unique features in light-matter interaction, opening doors to exciting new wave-based and quantum optical features. In this talk, I will give an overview of some of our ongoing research programs in the above topics, and will forecast future possibilities in these topics.

Zoom Link (QR Code)





**Nader ENGHETA** is the H. Nedwill Ramsey Professor at the University of Pennsylvania in Philadelphia, with affiliations in the Departments of Electrical and Systems Engineering, Physics and Astronomy, Bioengineering, and Materials Science and Engineering. He received his BS degree from the University of Tehran, and his MS and Ph.D. degrees from Caltech. His current research activities span a broad range of areas including photonics, metamaterials, electrodynamics, microwaves, nano-optics, graphene photonics, imaging and sensing

inspired by eyes of animal species, microwave and optical antennas, and physics and engineering of fields and waves. He has received several awards for his research including the Isaac Newton Medal and Prize from the Institute of Physics (UK), Max Born Award from the Optical Society, Ellis Island Medal of Honor, the IEEE Pioneer Award in Nanotechnology, the Gold Medal from SPIE, the Balthasar van der Pol Gold Medal from the International Union of Radio Science (URSI), the William Streifer Scientific Achievement Award, induction to the Canadian Academy of Engineering as an International Fellow, the Fellow of US National Academy of Inventors (NAI), the IEEE Electromagnetics Award, the Vannevar Bush Faculty Fellowship Award from US Department of Defense, the Wheatstone Lecture in King's College London, 2006 Scientific American Magazine 50 Leaders in Science and Technology, the Guggenheim Fellowship, and the IEEE Third Millennium Medal. He is a Fellow of seven international scientific and technical organizations, i.e., IEEE, Optical Society of America (OSA), American Physical Society (APS), Materials Research Society (MRS), International Society for Optics and Photonics (SPIE), International Union of Radio Science (URSI), and American Association for the Advancement of Science (AAAS). He has received the honorary doctoral degrees from the Aalto University in Finland in 2016, the University of Stuttgart, Germany in 2016, and Ukraine's National Technical University Kharkov Polytechnic Institute in 2017.

[Invited] 10:00 AM - 10:40 AM, 04 March (Thu)

## **Electronically Reconfigurable Metasurfaces for Active Wavefront Control in Ranging and Communications**

HARRY ATWATER, *California Institute of Technology, USA*

A grand challenge for photonics is the realization of comprehensively tunable metasurface nanoantenna arrays for dynamic, active control of the constitutive properties of light – amplitude, phase, wavevector and polarization, and to do so in systems with dramatically decreased size, weight, and power (SWaP). I will describe the status and outlook for electronically tunable and reconfigurable plasmonic and dielectric metasurfaces whose elements are reprogrammable, enabling a wide array of functions, including steering, focusing, and frequency multiplexing of scattered radiation. We have recently developed tunable chip-based metasurface phased arrays, operating in the C-band wavelength regime (1530-1565 nm) capable of electronic beam steering and focusing. I will also give an outlook for active metasurfaces for wavefront control in future LIDAR and laser-based beam steering space communication systems.

Zoom Link (QR Code)





**Harry ATWATER** is the Howard Hughes Professor of Applied Physics and Materials Science at the California Institute of Technology. Atwater's scientific effort focuses on nanophotonic light-matter interactions. His work spans fundamental nanophotonic phenomena, in plasmonics and 2D materials, and applications including active metasurfaces and optical propulsion. His current research in solar energy centers on high efficiency photovoltaics and photoelectrochemical processes for generation of solar fuels. Atwater was an early pioneer in nanophotonics and plasmonics he gave the name to the field of plasmonics in 2001. Atwater is a Member of US National Academy of Engineering, and a Web of Science Highly Cited Researcher. He is also a Fellow of the SPIE as well as APS, MRS, and the National Academy of Inventors. He is also the founding Editor in Chief of the journal ACS Photonics, and Chair of the LightSail Committee for the Breakthrough Starshot program. Currently Atwater is the Director for the Liquid Sunlight Alliance (LiSA), a Department of Energy Hub program for solar fuels. He is also founder of 5 early-stage companies, including Alta Devices, which set world records for photovoltaic cell and module efficiency.

[Invited] 10:50 AM - 11:30 AM, 04 March (Thu)

## **Metasurfaces for Vortex Generation, Multiplexing and Laser**

CHENGWEI QIU, *National University of Singapore, Singapore*

Interfacial engineering via the artificially constructed structures of ultrathin thickness compared to the wavelength has enabled a plethora of advanced manipulations of light-matter interactions. I will report some of the most recent developments in my group as well as in the field of the interfacial engineering of manipulation of light-matter interactions, via the artificially nanostructured metasurfaces. Amongst various applications of metasurfaces, I will focus on how to design vortex metasurfaces<sup>1</sup> to generate and multiplex orbital angular momentums (OAMs), with other degrees of freedom of light such as polarization and frequency. Furthermore, we will show some more recent and exciting results about high-purity orbital angular momentum lasing by synergize the metasurfaces and cavities. It may provide an alternative paradigm toward an extremely compact and multifunctional nanodevices resorting to the OAM states of the light. The multiplexing and hybridization of OAM states with other properties of light open up new opportunities for the advanced flat-profile optics.

Zoom Link (QR Code)





**Cheng-Wei QIU** received his B.Eng. (USTC) and Ph. D. (NUS) degree in 2003 and 2007, respectively. He was a Postdoctoral Fellow at Physics Department in MIT till the end of 2009. Since December 2009, he joined NUS as an Assistant Professor and was promoted to Associate Professor with tenure in Jan 2017. From 1st Jan 2018, he was promoted to Dean's Chair Professor in Faculty of Engineering, NUS. He was the recipient of the SUMMA Graduate Fellowship in

Advanced Electromagnetics in 2005, IEEE AP-S Graduate Research Award in 2006, URSI Young Scientist Award in 2008, NUS Young Investigator Award in 2011, MIT TR35@Singapore Award in 2012, Young Scientist Award by Singapore National Academy of Science in 2013, Faculty Young Research Award 2013 in NUS, SPIE Rising Researcher Award 2018, Young Engineering Research Award 2018, and Engineering Researcher Award 2021 in NUS. His research is known for the structured light for beam manipulation and nanoparticle manipulation. He has published over 300 peer-reviewed journal papers. He was Highly Cited Researchers in 2019 and 2020 by Web of Science. He has been serving in Associate Editor for various journals such as PhotoniX, Photonics Research, and Editor-in-Chief for eLight. He also serves in Editorial Advisory Board for Laser and Photonics Review, Advanced Optical Materials, and ACS Photonics.



[Keynote] 11:30 AM - 12:30 PM, 04 March (Thu)

## **Recent Progress in Circularly Polarized Metamaterial Antennas**

HISAMATSU NAKANO, *Hosei University, Japan*

Circularly polarized (CP) antennas have been receiving considerable attention in response to recent developments in modern wireless communication systems. This keynote speech presents recent progress in four CP metamaterial antennas (metaantennas), comparing them with the corresponding natural CP antennas: (1) metaline antenna, (2) metaloop antenna, (3) metaspiral antenna, and (4) metacurl antenna. Investigation reveals that metaline antenna (1) exhibits a CP beam-scanning characteristic with change in frequency. Analysis of metaloop antenna (2) finds that it possesses a counter CP dual band characteristic, i.e., left-handed CP radiation across a specific frequency band and right-handed CP radiation across a different frequency band. Discussion of metaspiral antenna (3) is directed toward CP beam-scanning capability in both the azimuth and elevation planes. Exploration of metacurl antenna (4) finds that the antenna can be made to radiate a left-handed CP wave and a right-handed CP wave, where both have the same maximum gain.

Zoom Link (QR Code)





**Hisamatsu NAKANO** has been with Hosei University since 1973, where he is currently a Professor Emeritus and a Special-appointment Researcher with the Electromagnetic Wave Engineering Research Institute attached to the graduate school. He has published over 340 articles in peer-reviewed journals and 11 books/book chapters. His significant contributions are the development of five integral equations for line antennas, the invention of an L-

shaped wire/strip antenna feeding method, and the realization of numerous wideband antennas. He received the H. A. Wheeler Award (1994), the Chen-To Tai Distinguished Educator Award (2006), and the Distinguished Achievement Award (2016), all from the IEEE Antennas and Propagation Society. He was also a recipient of The Prize for Science and Technology from Japan's Minister of Education, Culture, Sports, Science and Technology (2010). Most recently, he was selected as a recipient of the Antenna Award of the European Association on Antennas and Propagation, EurAAP, (2020).

## Student Paper Contest (SPC)

## Session I

2:30pm – 4:00pm, 04 March (Thu)

Singapore Time [ GMT+8]	Student Paper Contest (SPC) Presentation Session I -- Application Paper Track
2:30 PM - 2:45 PM	<i>Passive microwave spectral imaging with dynamic metasurface apertures</i> <b>Aaron V. Diebold</b> , Duke University, USA
2:45 PM - 3:00 PM	<i>2.5-dimensional miniaturized multifunctional active frequency selective surface</i> <b>Huangyan Li</b> , Nanjing University of Science and Technology, China
3:00 PM - 3:15 PM	<i>A compact beamsteering metasurface lens array antenna with low-cost phased array</i> <b>Ruolei Xu</b> , National University of Singapore, Singapore
3:15 PM - 3:30 PM	<i>Smart metasurface with self-adaptively reprogrammable functions</i> <b>Qian Ma</b> , Southeast University, China
3:30 PM - 3:45 PM	<i>Coding programmable metasurfaces based on deep learning techniques</i> <b>Tao Shan</b> , Tsinghua University, China
3:45 PM - 4:00 PM	<i>A radial transformation-optics mapping for flat ultra-wide-angle dual-polarized stacked GRIN MTM Luneburg lens antenna</i> <b>Yuanyan Su</b> , École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

## Student Paper Contest (SPC)

## Session II

4:20pm – 5:50pm, 04 March (Thu)

Singapore Time [ GMT+8]	Student Paper Contest (SPC) Presentation Session II -- Theory Paper Track
4:20 PM - 4:35 PM	<i>Non-Hermitian topological light steering</i> <b>Han Zhao</b> , University of Pennsylvania, USA
4:35 PM - 4:50 PM	<i>Topological polaritons and photonic magic angles in twisted <math>\alpha</math>-MoO<sub>3</sub> bilayers</i> <b>Guangwei Hu</b> , National University of Singapore, Singapore
4:50 PM - 5:05 PM	<i>Antireflection and wavefront manipulation with cascaded metasurfaces</i> <b>Fengyuan Yang</b> , National University of Singapore, Singapore
5:05 PM - 5:20 PM	<i>An optically driven digital metasurface for programming electromagnetic functions</i> <b>Xin Ge Zhang</b> , Southeast University, China
5:20 PM - 5:35 PM	<i>Metasurface-bounded open cavities supporting virtual absorption: free-space energy accumulation in lossless systems</i> <b>Angelica Marini</b> , Roma Tre University, Italy
5:35 PM - 5:50 PM	<i>Broadband nonreciprocal amplification in luminal metamaterials</i> <b>Emanuele Galiffi</b> , Imperial College London, UK

[Keynote] 9:00 AM - 10:00 AM, 05 March (Fri)

## **Huygens' Metasurfaces for Antenna Beamforming and Beamsteering**

GEORGE ELEFThERIADES, *University of Toronto, Canada*

We will describe the concept of the Huygens' metasurface which comprises co-located electric and magnetic dipoles forming an electrically dense array of Huygens' sources or scatterers. These engineered surfaces can be designed to control electromagnetic waves at will. Unlike traditional antenna transmitarrays, Huygens' metasurfaces can be made sub-wavelength thin and deprived of spurious Floquet modes, while preserving excellent matching characteristics. Huygens' metasurfaces can be used to manipulate the phase, magnitude and polarization of incident electromagnetic waves, including those from nearby elementary antennas, for a variety of applications. For example, Huygens' omega bi-anisotropic metasurfaces enable wave refraction at extreme angles without any reflections. We will review progress of such Huygens' Metasurfaces for antenna beamforming and beamsteering. Examples to be discussed include antenna focusing and lensing, high aperture efficiency/low-profile antennas, antenna aperture beamforming with simultaneous magnitude and phase control, and electronic beam steering.

Zoom Link (QR Code)





**George V. ELEFThERIADES** is a Professor in the Department of Electrical and Computer Engineering at the University of Toronto Canada where he holds the Velma M. Rogers Graham Chair in Engineering. Prof. Eleftheriades introduced the concept of using transmission lines to realize negative-index metamaterials in 2002. More recently he pioneered Huygens' metasurfaces, 2D analogues of metamaterials, and their antenna applications. Professor Eleftheriades received

the 2008 IEEE Kiyo Tomiyasu Technical Field Award, the 2015 IEEE AP-S John Kraus Antenna Award and the 2019 IEEE Antennas and Propagation Society's Distinguished Achievement Award. He is an IEEE Fellow and a Fellow of the Royal Society of Canada (Academy of Sciences). His research interests include electromagnetic and optical metamaterials, metasurfaces, antennas and components for broadband wireless communications, novel antenna beam-steering techniques, far-field super-resolution imaging, radars, plasmonic and nanoscale optical components, and fundamental electromagnetic theory.

[\[Invited\] 10:00 AM - 10:40 AM, 05 March \(Fri\)](#)

## **Symmetry Driven Photonics for New Active Functionality On-Chip**

LIANG FENG, *University of Pennsylvania, USA*

Symmetry and topology are fundamental notions existing in all kinds of natural systems, from spiral galaxies and hurricanes to amino acids in molecules and non-trivial topologically protected electronic states in condensed matter. A stream of photons is typically topologically trivial, nevertheless, its full-vector nature intrinsically endows light with full capability of creating and carrying unique symmetry and topology, especially non-Hermitian symmetries that cannot be easily implemented in condensed matter. Explorations of symmetry and topology on a photonic platform not only deepen our understanding of fundamental physics, but also enable novel material properties to facilitate technological breakthroughs for photonic applications. In this seminar, I will present our recent efforts on investigating the complex optical potentials with the non-Hermitian parity-time symmetry for the next generation of optical communication and information technology. We demonstrated an orbital angular momentum (OAM) microlaser that structures and twists the lasing radiation at the microscale, which can provide an additional OAM-based information dimension to meet the growing demand for information capacity. By strategically interfacing non-Hermitian photonic materials and topological physics, we realized the dynamic control of robust topological transmission links of light inside the bulk of a photonic topological insulator, routing optical signals in a highly flexible and scalable manner.

Zoom Link (QR Code)





**Liang FENG** is an Associate Professor of Materials Science & Engineering (MSE) and Electrical and Systems Engineering (ESE) at the University of Pennsylvania. He received his Ph.D. in Electrical Engineering from UCSD in 2010 and was subsequently a postdoc researcher in the Department of Electrical Engineering at California Institute of Technology and NSF Nanoscale Science and Technology Center at UC Berkeley. Prior to joining Penn in 2017, he was an assistant professor of SUNY Buffalo from 2014 to 2017. Currently his

research interests include optical and photonic materials, quantum optics, nanophotonics, and optoelectronics. He has authored and coauthored ~70 papers including Science, Nature Materials, Nature Photonics and PRL. He is an OSA fellow and a recipient of Sloan Research Fellow, NSF CAREER and ARO Young Investigator awards.



[Invited] 10:50 AM - 11:30 AM, 04 March (Thu)

## **The Fundamentals and Frontiers of Surface Electromagnetics**

FAN YANG, *Tsinghua University, China*

From frequency selective surfaces to Huygens metasurfaces, novel electromagnetic surfaces have been emerging in both scientific exploration and engineering applications. Many intriguing phenomena occur on these surfaces, and novel devices and applications have been proposed accordingly, which have created an exciting paradigm in electromagnetics, the so-called “Surface Electromagnetics (SEM)”. This presentation will review the development of various electromagnetic surfaces, as well as the state-of-the-art concepts and designs. The fundamentals of SEM will be summarized and the frontier topics will be prospected, including their promising applications in microwaves, THz, and optic regimes.

Zoom Link (QR Code)





**Fan YANG** received the B.S. and M.S. degrees from Tsinghua University, and the Ph.D. degree from University of California at Los Angeles. Currently, he is a Professor at Tsinghua University. Prof. Yang's research interests include antennas, surface electromagnetics, computational electromagnetics, and applied electromagnetic systems. He has published six books, seven book chapters, and over 400 journal articles and conference papers. Dr. Yang served as an Associate Editor for IEEE Trans. Antennas Propagation (TAP), Associate Editor-in-Chief for Applied Computational Electromagnetics Society (ACES) Journal, and TPC chair of 2014 IEEE AP-S International Symposium. He is an IEEE Fellow and ACES Fellow, as well as an IEEE APS Distinguished Lecturer.

[Keynote] 11:30 AM - 12:30 PM, 05 March (Fri)

## **Information Metasurfaces and Intelligent Metasurfaces**

TIE JUN CUI, *Southeast University, China*

We propose to represent metamaterials by using encoded digital states, instead of the effective medium parameters, evolving a new kind of metamaterials – information metamaterials and/or information metasurfaces. Based on different digital coding sequences on the physical platform, the information metasurfaces can be used to control both electromagnetic waves and digital information flexibly, bridging the physical world and digital world. More importantly, equipped with field programmable gate array (FPGA), the information metasurface can manipulate the electromagnetic waves and process the digital messages in programmable ways. By integrating various algorithms and software in FPGA, software metasurfaces are developed by designing various machine learning algorithms in FPGA, the information metasurface can further reach artificial-intelligence (AI) capabilities. Several system-level applications of the information metasurfaces are presented, including real-time microwave imaging, new architecture wireless communications, and intelligent walls for smart home and smart cities.

Zoom Link (QR Code)





**Tie Jun CUI** is the academician of Chinese Academy of Sciences and the Chief Professor of Southeast University, Nanjing, China. He authored or co-authored two books and published over 500 peer-review journal papers, which have been cited by more than 33000 times (H-index 91, Google Scholar). He proposed the concepts of digital coding metamaterials, programmable metamaterials, and information metamaterials, and realized their first demonstrations. Dr. Cui received the National Natural Science Awards of China in 2014 and 2018, respectively. Based on Clarivate Analytics, he was a Highly Cited Researcher (Web of Science) in 2019 and 2020, and his research has been widely reported by Nature News, Science, MIT Technology Review, Scientific American, New Scientists, etc. Dr. Cui is an IEEE Fellow.

[Keynote] 2:30 PM - 3:30 PM, 05 March (Fri)

## **Metasurfaces for Shaping Reflected and Scattered Waves**

SERGEI TRETYAKOV, *Aalto University, Finland*

In this presentation, we will discuss recent research results on engineering reflection and absorption properties of metasurfaces. We will consider anomalous reflectors of different types and “multi-channel” metasurfaces that control reflection and absorption of waves coming from several different directions, including both reciprocal and nonreciprocal devices, realized using time-space modulated metasurfaces. Finally, we will explain how the fields reflected and scattered from finite-sized anomalous reflectors can be analytically calculated. These results are especially relevant for developments of future telecommunication systems based on reconfigurable intelligent surfaces.

Zoom Link (QR Code)





**Sergei A. TRETYAKOV** received the Dipl. Engineer-Physicist, the Candidate of Sciences (PhD), and the Doctor of Sciences degrees (all in radiophysics) from the St. Petersburg State Technical University (Russia), in 1980, 1987, and 1995, respectively. From 1980 to 2000 he was with the Radiophysics Department of the St. Petersburg State Technical University. Presently, he is professor of radio science at the Department of Electronics and Nanoengineering, Aalto University, Finland. His main scientific interests are electromagnetic field theory, complex media electromagnetics, metamaterials, and microwave engineering. He has authored or co-authored six research monographs and more than 300 journal papers. Prof. Tretyakov served as President of the Virtual Institute for Artificial Electromagnetic Materials and Metamaterials ("Metamorphose VI"), as General Chair, International Congress Series on Advanced Electromagnetic Materials in Microwaves and Optics (Metamaterials), from 2007 to 2013, and as Chairman of the St. Petersburg IEEE ED/MTT/AP Chapter from 1995 to 1998. Prof. Tretyakov is an IEEE Fellow.

[Invited] 3:30 PM - 4:10 PM, 05 March (Fri)

## **Latest Advances in Magnetless Nonreciprocal Metasurfaces**

CHRISTOPHE CALOZ, *ESAT-WAVECORE-META, Belgium*

Magnetless Nonreciprocal Metasurfaces represents one of the most vibrant fields of modern electromagnetic science and technology. This talk will present the latest advances of our research group in this area. First, it will introduce nonreciprocity by recalling its engineering and physics definitions, historical milestones and ferrite-technology principles. Motivated by the drawbacks of that technology, it will then establish the key conditions for nonreciprocity in terms of time-reversal symmetry breaking, and deduce from them three routes for magnetless that have been recently explored, namely asymmetric nonlinearity, spacetime modulation and transistor loading. Third, it will show that the most promising of these routes is the transistor-loaded particle one that it will describe in some details. Fourth, it will note that metasurfaces represent ideal embodiments of metamaterials for magnetless nonreciprocity, and subsequently describes the Generalized-Sheet Transition Condition (GSTC) synthesis allowing to design efficient bianisotropic metasurfaces [1]. Finally, it will overview several examples of metamaterial magnetless nonreciprocity applications recently developed in the speaker's group, including nongyrotropic/gyrotropic rotators and isolators, nonreciprocal refractive and birefringent systems, nonreciprocal specular transformers, energy sinking cavities and angle-independent absorbers/amplifiers.

[1] K. Achouri and C. Caloz, Electromagnetic Metasurfaces: Theory and Applications. Wiley - IEEE Press, 2020.

[Zoom Link \(QR Code\)](#)





**Christophe CALOZ** is a BOFZAP Research Professor and the head of the META Research Group at KU Leuven, as well as an adjunct professor and holder of a Tier-I Canada Research Chair in Metamaterials at Poly Montréal. He has authored and co-authored over 750 technical conference, letters, and journal papers, 17 books and book chapters, and he holds a dozen of patents. His works have generated over 30,000 citations and he is a Thomson Reuters Highly Cited Researcher. He received many distinctions and awards. He

has been Fellow of the Institute of Electrical and Electronics Engineers (IEEE) since 2010, a Distinguished Lecturer of the Antennas and Propagation Society (AP-S) from 2014 to 2016, a Fellow of the Canadian Academy of Engineering (CAE) since 2016, and a Fellow of the Optical Society of America (OSA) since 2019. His research interests include all fields of theoretical, computational, and technological electromagnetics, with strong emphasis on emergent and multidisciplinary topics, such as metamaterials and metasurfaces, nanoelectromagnetics, quantum and space-time electrodynamics, photophononics, exotic antenna systems and real-time radio/photon processing.



[Invited] 4:20 PM - 5:00 PM, 05 March (Fri)

## **Hyperbolic Metamaterials for Waveguiding and Polarization Control**

ANATOLY ZAYATS, *King's College London, United Kingdom*

The development of metamaterials and metasurfaces has recently led to numerous opportunities in manipulating electromagnetic fields through designing unusual linear and nonlinear optical properties and devices. Variety of metamaterial platforms based on dielectric and plasmonic platforms has been proposed. Hyperbolic metamaterials are a class of anisotropic metamaterials which can be constructed in all frequency ranges from UV to RF using plasmonic or semiconductor nanostructures and components. Due to their specific isofrequency surfaces, they support high wavenumber modes and are crucial for achieving high-resolution imaging, subwavelength waveguiding, enhanced nonlinearities. In this talk, we will overview properties of hyperbolic metamaterials and metasurfaces in both visible and RF spectral ranges and their applications in controlling waveguiding, bio- and chemical sensing and active control of polarisation of electromagnetic radiation.

Zoom Link (QR Code)





**Anatoly V. ZAYATS** is a Chair in Experimental Physics and the head of the Photonics and Nanotechnology at the Department of Physics, King's College London, where he also leads Nano-optics and Near-field Spectroscopy Laboratory ([www.nano-optics.org.uk](http://www.nano-optics.org.uk)). He is a Co-Director of the London Centre for Nanotechnology and the London Institute of Advanced Light Technologies. His current research interests are in the areas of nanophotonics, plasmonics, metamaterials, optical spin-orbit effects, scanning probe microscopy, nonlinear and ultrafast optics and spectroscopy, and optical properties of surfaces, thin films, semiconductors, and low-dimensional structures. He is a founding co-editor-in-chief of *Advanced Photonics*. He is a Fellow of the Institute of Physics, the Optical Society of America, SPIE and the Royal Society of Chemistry.

[Keynote] 5:00 PM - 6:00 PM, 05 March (Fri)

## Metamaterials that Travel Faster than Light

JOHN PENDRY, *Imperial College, United Kingdom*

"Nothing can travel faster than light" is not a correct statement. Many things can and do. Think of a wave breaking at an angle on the seashore. The point of impact travels along the beach very fast if the angle is a shallow one and can travel infinitely quickly as the angle tends to zero. I shall speak about metamaterials in which the structure moves with a velocity close to or faster than light giving rise to phenomena not seen in static structures. The structures naturally break time reversal invariance giving rise to effects for photons that resemble electrons in a magnetic field. In another realisation the metamaterial grabs hold of the field lines of incident radiation and squeezes them into a tightly formed pulse forming a supercontinuum of intense radiation.

Zoom Link (QR Code)





**John PENDRY** is a condensed matter theorist working at Imperial College London. His early work addressed electronic and structural properties of surfaces developing the theory of low energy diffraction, EXAFS, and of electronic surface states later moving on to studies of transport in disordered systems. In the mid 1990's he turned his attention to metamaterials and proposed several structures which radically influenced the development of the field leading to the experimental discovery

of negative refraction by the Smith group and later, also in collaboration with David Smith, the design of a cloak of invisibility. His investigation of negative refraction led to the discovery that it is theoretically possible to design a lens whose resolution is limited only by the perfection of manufacture, not by the well-known Abbé law which limits resolution to the order of the wavelength. The technique of transformation optics which he pioneered has led to many applications in the field of plasmonics, particularly building on the perfect lens concept and showing how to concentrate light into sub nanoscale volumes. His most recent work is the topic of today's talk and moves the study of metamaterials on to structures that vary in time as well as in space.

## Notes

## Notes