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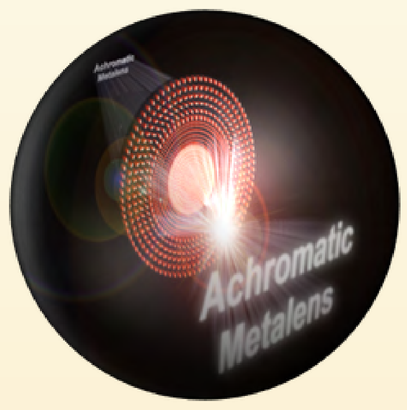
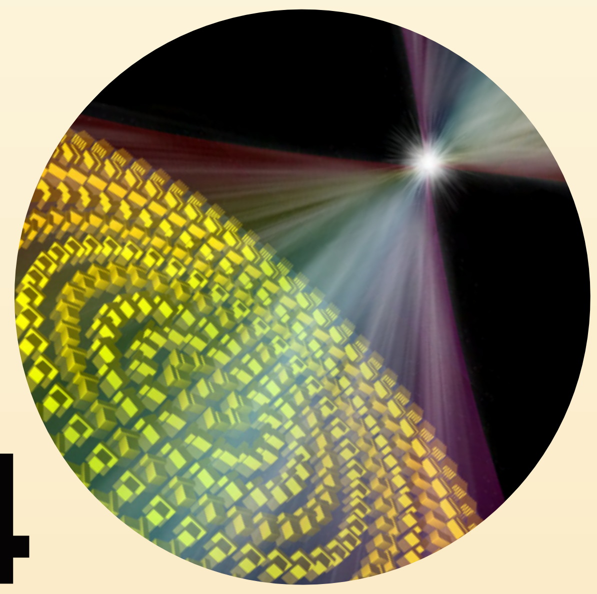
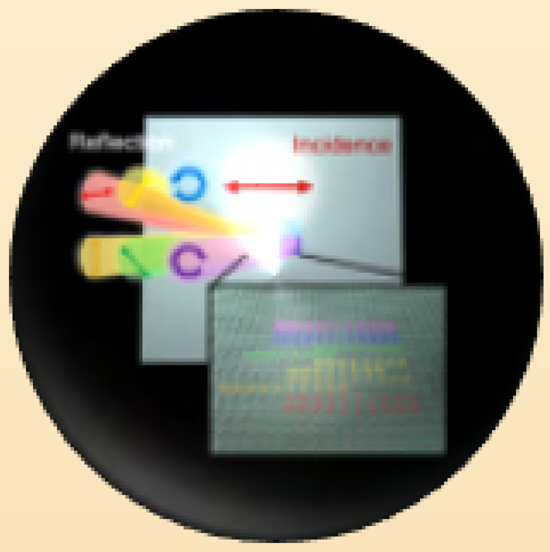
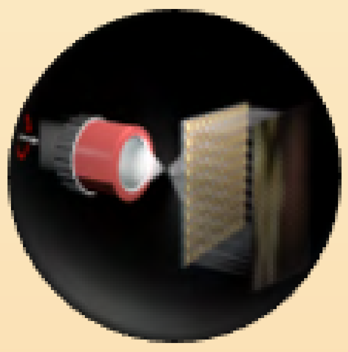


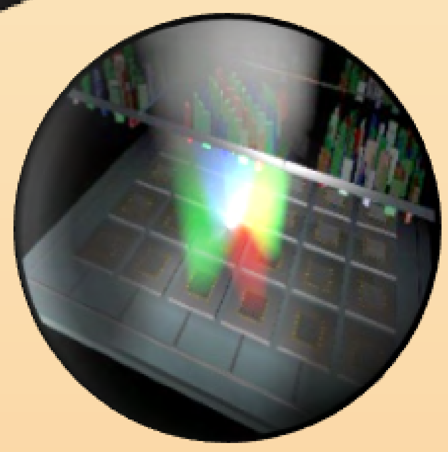
META-LENS WORLD SUMMIT 2024

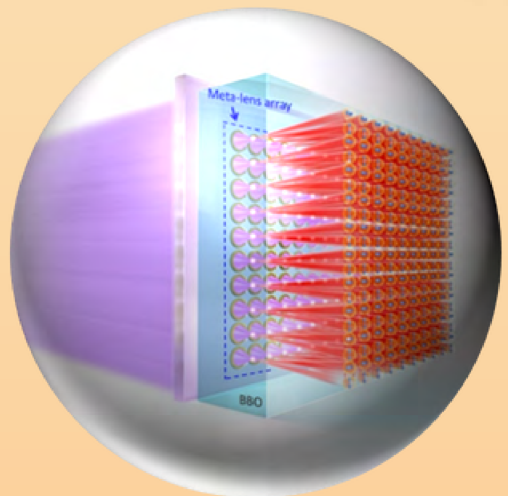
cum HKIAS Distinguished Lecture by Professor Sir John Pendry











Date: 23 October 2024 (Wed)

Time: 9:00am - 5:30pm

Venue: HKIAS Lecture Theatre, LG/F, Academic Exchange Building, City University of Hong Kong

Program & abstract

Online Participation via. Zoom
Meeting ID：82505882860
Pw：012414

Sir John PENDRY
Imperial College London

Takuo TANAKA
RIKEN, Japan

Shumin XIAO
Harbin Institute of Technology

Che Ting CHAN
Hong Kong University of Science and Technology

Ping SHENG
Hong Kong University of Science and Technology

Shuang ZHANG
The University of Hong Kong

Jie ZHU
Tonji University

Jensen LI
Hong Kong University of Science and Technology

Jinghua TENG
Agency for Science, Technology and Research (A*STAR)

Shuming WANG
Nanjing University

Shubo WANG
City University of Hong Kong

Professor Sir John Pendry will be giving a HKIAS Distinguished Lecture Series titled “Materials that move faster than light” on 23 October 2024 (Wednesday) 11:00am at HKIAS Lecture Threatre

~ All are welcome! ~
Registration:
https://go.cityu.hk/gzffb6

Organized by Prof. Din Ping Tsai
Chair Professor
Department of Electrical Engineering
City University of Hong Kong
Email: dptsai@cityu.edu.hk

Sponsored and supported by :

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META-LENS WORLD SUMMIT 2024

CUM HKIAS DISTINGUISHED LECTURE BY PROFESSOR SIR JOHN PENDRY

PROGRAM

Time	Title	Speaker
09:00-09:05	Opening	Prof. Chi Hou Chan Prof. Din Ping Tsai
09:05-09:35	Some new forms of magnetic photonic crystals: disorder photonic alloy and gyromagnetic double-zero-index material	Prof. Che Ting Chan
09:35-10:05	Synthesizing complex-frequency waves to compensate for optical loss of polaritons	Prof. Shuang Zhang
10:05-10:35	High-performance all-dielectric metalenses and their applications	Prof. Shumin Xiao
10:35-11:00	***Tea Break (25 mins) *Please stay for the photo session****	
11:00-11:05	Opening of Sir John Pendry’s DL	Prof. Shuk Han Cheng
11:05-12:05	Materials that move faster than light	Prof. Sir John Pendry
12:05-12:35	Metasurfaces for spectroscopic molecular detection	Prof. Takuo Tanaka
12:35-14:00	***Lunch (1hr25m)***	
14:00-14:30	Flat lens for sub-diffraction limit focusing imaging and lithography	Prof. Jinghua Teng
14:30-15:00	Enhanced Ultrasonic Transmission and Focusing through Dense Barriers	Prof. Jie Zhu
15:00-15:30	Optical imaging based on metasurfaces	Prof. Shuming Wang
15:30-16:00	Geometric phases of structured optical and acoustic fields	Prof. Shubo Wang
16:00-16:20	***Tea Break (20 mins)***	
16:20-16:50	From hybrid entangled states to quantum holographic eraser using metasurfaces	Prof. Jensen Li
16:50-17:20	Broadband Microwave Impedance Matching with Near-total Absorption	Prof. Ping Sheng
17:20-17:30	Award Ceremony and Closing	Prof. Din Ping Tsai

Che Ting CHAN

Hong Kong University of Science and Technology

C.T. Chan received his BSc degree from the University of Hong Kong in 1980 and his PhD degree from the University of California at Berkeley in 1985. He is the Daniel C K Yu Professor of Science, Chair Professor of Physics, and the Director of Research Office of HKUST. He has been elected a Fellow of the American Physical Society and the Physical Society of Hong Kong and a member of the Hong Kong Academy of Sciences.

Some new forms of magnetic photonic crystals: disorder photonic alloy and gyromagnetic double-zero-index material

In this talk, we will discuss our group's progress on the topological aspects of photonic crystals, introducing the concept of photonic alloys as non-periodic topological materials. These new disordered materials show that combining non-magnetized and magnetized components in a 2D photonic crystal can lead to non-trivial topology and edge states characterized by the winding of the reflection phase. Notably, we observe non-reciprocal chiral edge states due to a local breakdown of time-reversal symmetry. Additionally, we present gyromagnetic double-zero-index metamaterials (GDZIM), which have zero scalar permittivity and a unique magnetic property with a zero determinant. GDZIMs are excellent for generating complex optical pulses, known as spatiotemporal vortex pulses, linked to the bulk Dirac point. Our key discovery is that the stability of GDZIMs stems from a unique relationship at the topological transition point, revealing connections between zero-refractive-index photonics, topological photonics, and singular optics.

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Shuang Zhang

The University of Hong Kong

Shuang Zhang is a chair Professor and interim Head of the Department of Physics at the University of Hong Kong. He obtained his PhD in Electrical Engineering from the University of New Mexico. Thereafter he worked as postdoc at UIUC and UC Berkeley. He joined the University of Birmingham, UK as a Reader in 2010 and was promoted to professor in 2013. Prof. Zhang joined the University of Hong Kong as a Chair Professor in 2020. He was the recipient of IUPAP Young Scientist Award in Optics (2010), ERC consolidator grant (2015-2020), Royal Society Wolfson Research Award (2016-2021), and New Cornerstone Investigator program (2023-2028). He was elected OSA fellow in 2016, APS fellow in 2022, and has been on the list of highly cited researchers (by Clarviate) since 2018.

Synthesizing complex-frequency waves to compensate for optical loss of polaritons

Polaritons, including surface plasmon polaritons (SPPs) and phonon polaritons (PhPs), have emerged as a highly promising candidate for constructing nanophotonic circuits, enabling the development of ultra-compact and high-speed optical devices. Utilizing polaritons in nanophotonics provides a pathway to overcoming the diffraction limit of light, allowing for the manipulation of light at the nanoscale. However, the intrinsic losses have hindered many loss-sensitive applications based on polaritons, including bio-sensing and sub-diffractional limit imaging. Complex frequency waves with virtual gain have been proposed to counteract losses in plasmonic/phononic materials for various applications, including super-resolution imaging1,2,3, slow light4, coherent virtual absorption5, and virtual PT symmetry6. Complex frequency waves feature temporal attenuation, which requires a precise exponential decay profile in time and time-gated measurements that are challenging for experimental implementation in optics. to address this challenge, we synthesize CFW signals using a multi-frequency approach. We exploit the fact that a truncated CFW can be expressed as combination of multiple frequency components with coefficients following a Lorentzian spectral lineshape through the Fourier transformation. Based on this method, we demonstrate dramatically improved superimaging resolution with a SiC superlens2, improved sensitivity of molecular sensing with plasmonic structures7, and restoration of lossless propagation of polaritons8.

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[1]Archambault, A., Besbes, M. & Greffet, J. J. Superlens in the time domain. Phys. Rev. Lett. 109, 097405 (2012).
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[7] Zeng, K et al, Synthesized complex-frequency excitation for ultrasensitive molecular sensing, eLight, 4, 1 (2024)
[8] Guan F. et al, Compensating losses in polariton propagation with synthesized complex frequency excitation, Nature Materials (2024) https://doi.org/10.1038/s41563-023-01787-8

Shumin XIAO

Harbin Institute of Technology

Shumin Xiao received the Ph.D. degree from the Department of Electrical Engineering and Computer Science, Purdue University, West Lafayette, IN, USA, in 2010.She joined Harbin Institute of Technology Shenzhen as full professor in 2011. Her current research interests include integrated optoelectronics, semiconductor devices, metamaterials, plasmonic physics and devices, nonlinear optics, and nanophotonics.

High-performance all-dielectric metalenses and their applications

In this talk, we will present our recent progress on high-efficiency metalenses based on various dielectric materials such as Si, Si3N4, and TiO2. With the improvement of nanofabrication technology, we show that the focusing efficiency of broadband achromatic metalens can be preserved at a record high value. The corresponding on-chip integration and application in STED imaging have also been demonstrated too. By further utilizing the nonlocal concept, we further show the narrowband nonlocal metalens with a record high Q factor.

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Sir John PENDRY
Imperial College London

John Pendry is known for his work on metamaterials, electromagnetic materials thatowe their properties more to their internal micro-structure, than to their chemical composition. He has worked at Imperial College London since 1981 where he served as Dean, Head of Physics, and Principal Faculty of Physical Sciences. He is a Fellow of the Royal Society, Foreign Associate of the US Academy of Sciences, and a Foreign Member of the Norwegian Academy of Sciences. Amongst his several awards are the UNESCO Niels Bohr Gold Medal, the Kavli prize for nanotechnology, the Dan David Prize for nanotechnology, and the Kyoto Prize laureate in Advanced Technology

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Materials that move faster than light

Einstein’s theory of relatively sets a limit to the speed of an object: no faster than light. But there is more than one sort of motion: here we are concerned with virtual motion where a material changes its properties in time but nothing materials moves: think of a wave on the ocean which moves but without transporting any water. When things move that fast they strongly influence the way light moves through them. They break time reversal symmetry, they can capture light and amplify it, they can spontaneously emit radiation. I shall talk about the theory behind these processes and review the current state of experiments that are realising this vision.

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Takuo TANAKA
RIKEN, Japan

Takuo Tanaka is a chief scientist of RIKEN. He received his PhD degree in 1996 from Osaka University. After that, he joined faculty of Engineering Science, Osaka University as an assistant professor. In 2003, he moved to RIKEN as a research scientist in Nanophotonics Laboratory. He was promoted to associate chief scientist in 2008 and to chief scientist in 2017. His research background is three-dimensional microscopy such as confocal microscope and two-photon microscope. Recently, he is studying about nanophotonics, plasmonics, and metamaterials fields with developing many new nanofabrication techniques. He has also experimental and theoretical experiences about high precision optical measurements and spectroscopy.

Metasurfaces for spectroscopic molecular detection

Metasurface absorbers are applied in infrared spectroscopic molecular detection devices. Highly sensitive sensing techniques for biological and chemical materials are becoming increasingly essential in our daily lives. Recently, metamaterial absorbers have been utilized to enhance the sensitivity of IR spectroscopy. Due to their plasmonic enhancement and resonant coupling between excited plasmons and molecules, molecular sensitivity at the atto-molar level has been achieved [1].

To further improve sensitivity, it is crucial to introduce analyte molecules into the hot spot regions of the metamaterial absorber. A 3D metamaterial device incorporating nanofluidics was proposed to precisely introduce target molecules into these hot spot regions [2]. The structure comprises a metal square-disk array and a metal mirror separated by a nanofluidic channel. When a molecule with an absorption spectrum overlapping the metamaterial's resonant mode is introduced into the nanofluidic channel, a strong interaction between the molecule and the metamaterial is excited, generating reflected light within the metamaterial's absorption band. Using this device, sensitivity at a molecular density of approximately 10-4 molecules/Å2 was achieved.

The sensitivity also depends on the density of hot spots in the metamaterial. To increase the density of hot spots, we designed and fabricated a vertically aligned MIM (v-MIM) structure with a nano-gap of 25 nm. This metamaterial was applied to carbon dioxide and butane detection, designed to exhibit resonances at 4033 cm-1 and 2945 cm-1, which spectrally overlap with the C=O and -CH2 vibration modes, respectively. Owing to its small footprint, the v-MIM structure allows for increased integration density and enables the detection of a 20 ppm concentration with suppressed background and high selectivity in the mid-infrared region [3]. As a more physically robust structure, the 3D co-axial double cylinder metamaterial absorber and its experimental results will also be presented.

References:
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Jinghua TENG

*Agency for Science, Technology and Research (A*STAR)*

Dr. Jinghua Teng is a Senior Principal Scientist in the Institute of Materials Research and Engineering (IMRE), Agency for Science, Technology and Research (A*STAR), Singapore, and an Adjunct Professor in the National University of Singapore. He has extensive experiences in both use-inspired basic research and technology translation through industry collaborations. He has published over 260 journal papers, made over 290 conference presentations and filed over 40 primary patents with many licensed out or used in industry collaborations. His research interests embrace 2D optoelectronics, nanophotonics, metasurfaces and metamaterials, plasmonics, THz technology, and semiconductor materials and devices. He is a Fellow of OPTICA and SPIE.

Flat lens for sub-diffraction limit focusing imaging and lithography

The objective lens is a key component determining the performance of most optical systems. The resolution of the objectives is restricted by the fundamental diffraction of light as elaborated in Abbe and Rayleigh diffraction limit. The emergence of metaoptics brings opportunities for sophisticated light field control to break the diffraction limit and enhance the capability of optical systems. In this talk, I will introduce our work on super-critical lens fabricated in various types of materials with sub-diffraction limit focusing capability for applications in high resolution confocal imaging and direct laser writing. I will also briefly introduce tunable optical response and flat optics enabled by active media such as phase change materials, 2D semiconductors and 2D ferroelectric materials for potentially ultracompact and versatile optical system development.

Jie ZHU

Tonji University

Dr. Jie Zhu is a distinguished professor at the Institute of Acoustics, School of Physical Science and Engineering, Tongji University, and a visiting professor at City University of Hong Kong. He has been systematically engaged in basic frontier research and application exploration in the fields of physical acoustics and sequential acoustic materials for a long time, published papers in academic journals such as Nature Physics for many times, and presided over and undertaken a number of research projects of the major research plans of the NSFC, key research and development projects of the Ministry of Science and Technology and the Research Grants Council of the Hong Kong S.A.R.. He is currently a council member of the Acoustical Society of China, an executive council member of the Metamaterials Branch of the Chinese Materials Research Society, and an editorial board member of the journals Ultrasonics and Advanced Devices & Instrumentation. He has been a member of the organizing committee or branch chairman of many international conferences such as Internoise.

Enhanced Ultrasonic Transmission and Focusing through Dense Barriers

The transmission of ultrasonic waves through dense barriers is often hindered by the impedance mismatch between the background medium and the dense material, which significantly limits the practical applications of high-intensity focused ultrasound. To overcome this challenge, we have developed an innovative inverse optimization approach for designing a set of acoustic meta-lenses. These meta-lenses are designed to improve the transmission and focusing capabilities of ultrasonic waves as they traverse dense barriers. Our comprehensive simulations and experimental results indicate that the use of these meta-lenses can enhance the transmitted power by over ten times compared to conventional methods without such lenses. Furthermore, the focal distance can be adjusted by modifying the geometric parameters of the meta-lenses, ensuring efficient focusing even when the acoustic barriers have varying thicknesses. This enhancement in transmission efficiency opens up new possibilities for applications such as underwater wireless signal transmission and energy harvesting.

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Shuming WANG

Nanjing University

Shuming Wang, professor for School of Physics, Nanjing University, specializes in nanophotonics, metasurfaces (metamaterials), plasmonics, and quantum optics. He has received the National Science Fund for Distinguished Young and the Forth Jiangsu Youth Optical Science and Technology Award. Prof. Wang has authored more than 80 research publications, with more than 4000 citations.

Optical imaging based on metasurfaces

Ideal imaging technique simultaneously requires the three-dimensional (3D) high spatial-resolution and the high spectral-resolution. To date, while compact 3D imaging technique and spectrometer have been individually developed, the combination of these techniques has only been realized in cumbersome systems, significantly limiting their practical applications. A long-standing and critical challenge is how to integrate the 3D spatial-resolution and the spectral-resolution into a single nanophotonic device. Herein, based on the precise wavefront control of metasurface and deep-leaning algorithm, we experimentally demonstrate the first ultracompact spectral light field imaging (SLIM) camera. Owing to the high dispersion of metalens, both the 3D position information and the spectrum can be re-constructed without sacrificing the light throughput. The demonstrated spectral-resolution is as high as 4nm and the spatial-resolution reaches the diffraction limit, enabling the capability of SLIM in precise 3D imaging and material discrimination. Moreover, by using the end-to-end method, the real time facial recognition based on transversely dispersive metalens array has been achieved. By employing an inverse-design method, we demonstrate a pixel-level metasurface-based Bayer-type colour router, with the brightness twice as high as that of a commercial camera.

Shubo WANG

City University of Hong Kong

Dr Shubo Wang is an Associate Professor in the Department of Physics at City University of Hong Kong. He is interested in general wave physics including angular momentum, singular optics, non-Hermitian optics, metamaterials, photonic crystals, and optical forces. He has published ~50 papers in peer reviewed journals including Nature Communications, Science Advances, PNAS, and Physical Review Letters, among which some are selected as "Editors' Suggestion", highlighted in Nature Photonics, and received media coverage by EurekAlert, Phys.org, etc. He has delivered 23 invited/keynote talks at international conferences. He received the NSFC Excellent Young Scientists Fund and William Mong Outstanding Paper Award.

Geometric phases of structured optical and acoustic fields

The concept of geometric phase had a profound impact on physics since it was introduced by M. V. Berry. Geometric phase turns out to be a powerful tool for wave manipulations. In this talk, I will introduce our studies about the geometric phases of structured optical/acoustic fields. We find that the geometric phase of structured near fields in optical scattering systems can be applied to define a real-space spin Chern number, which is intrinsically quantized and equal to the structure's Euler characteristic [1, 2]. This spin Chern number decides the global topological properties of the interface polarization singularities. Common wisdom believes that the spin-redirection and Pancharatnam-Berry geometric phases are absent in acoustics due to the spin-0 nature of sound waves. We demonstrate that these geometric phases can emerge in structured sound fields in metamaterials and metasurfaces [3-5], which enables the control of sound waves beyond the limitations of conventional propagation phase and resonant phase.

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[5] W. Xiao, W. Kuang, S. Huang, S. Liang, D. P. Tsai, and S. Wang, arXiv:2408.03513 (2024).

Jensen LI

Hong Kong University of Science and Technology

Professor Jensen Li is a professor in the Department of Physics at Hong Kong University of Science and Technology. He is working on optical metasurfaces, non-Hermitian systems, transformation optics and acoustic metamaterials. He has published more than one hundred peer-reviewed articles. His research group in Hong Kong and previously in UK has been supported by research grants from Hong Kong RGC and EU. He has led a collaborative research project on "Non-Hermitian Systems in Optics and Acoustics" across several local universities in Hong Kong. Professor Li is an elected member of Hong Kong Young Academy of Sciences and received Croucher Senior Research Fellowship in 2022.

From hybrid entangled states to quantum holographic eraser using metasurfaces

Extensive exploration of quantum erasers involving physical double slits or virtual paths like orbital angular momentum has been demonstrated to probe the wave-particle duality of light within quantum mechanics. Here, with the aid from using metasurfaces to construct hybrid entangled state between polarizations and holograms, we demonstrate quantum erasing action visualized using holograms. Specifically, we take two abstract holographic routes as the which-path information. We then mark hologram paths of the signal photon with the polarization of the idler photon of an entangled photon pair. We further demonstrate that the holographic paths of the signal photon can be erased via a complementary polarization projection of the idler photon. The result is manifested as selective erasure of specific hologram regions with various inserted erasers. Our work shows application of metasurfaces in constructing hybrid-entangled state with holograms, potentially useful for robust quantum communications and anti-counterfeit technologies with quantum degrees of freedom.

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Ping SHENG

Hong Kong University of Science and Technology

Ping Sheng is a senior member of the Institute for Advanced Study and Professor Emeritus at HKUST. Since October 2023 he is also an Associate of Clare Hall College in Cambridge University. Prof. Sheng obtained his BSc in Physics from the California Institute of Technology, and PhD in Physics from Princeton University in 1971. After a stay at the Institute for Advanced Study, Princeton, Ping joined RCA David Sarnoff Research Center in 1973. In 1979 he joined the Exxon Corporate Research Lab, where he served as the head of the theory group during 1982-86. In 1994 Ping joined the HKUST as a professor of physics and served as the head of the physics department from 1999 to 2008.
Prof. Sheng is a Fellow of the American Physical Society and a Member of the Asia Pacific Academy of Materials. He served as the Executive Editor of Solid State Communications, a Division Associate Editor of Physical Review Letters and a member of the editorial board of New Journal of Physics. He was awarded the Brillouin Medal by the International Phononics Society in 2013, the Rolf Landauer Medal by the ETOPIM Society in 2018, and the Bloch Prize in 2021. Prof. Sheng was elected a member of the Hong Kong Academy of Sciences in 2019.
Prof. Sheng has published more than 480 papers with a total of over 53,000 citations, with an h-index of 102 (by Google Scholar). He has presented over 350 keynote, plenary or invited talks at international meetings and conferences. His research interests include acoustic metamaterials, nanostructured carbon, giant electrorheological fluids, fluid-solid interfacial phenomena, and effective medium theory of composites. Prof. Sheng's research has led to the founding of a successful startup company, the Acoustic Metamaterials Group.
Prof. Sheng now resides with his wife in Cambridge, UK.

Broadband Microwave Impedance Matching with Near-total Absorption

Impedance matching with vacuum is always an important consideration for microwave absorption. In this talk I introduce a novel approach for generating broadband impedance matching by using a metallic ring structure placed above a metallic substrate with a designed distance. The electric dipole resonance in the metallic, generated by the incident microwave, can be converted into two magnetic resonances through the interaction with the image ring current. By adding patch resistors to the metallic ring, the whole structure can impedance match with the vacuum, leading to near-total absorption. The absorption spectrum can be further extended by implementing a hierarchical structure comprising of smaller metallic rings. We show that the final spectrum can extend from 3 to 40 GHz, with 99% absorption. The overall thickness of the final sample is 14.2 mm, only 5% over the theoretical minimum thickness dictated by the causality limit[1].

*This work represents a collaboration with Sichao Qu and Yuxiao Hou.

[1] PNAS 118 (36) e2110490118 (2021).