META

Photonic Metamaterials: From Random to Periodic

Topical Meeting and Tabletop Exhibit

June 5-8, 2006

Grand Bahama Island, The Bahamas
Westin Grand Bahama Island Our Lucaya Resort,
Grand Island, The Bahamas

Hotel Reservation Deadline: May 2, 2006
Pre-Registration Deadline: May 12, 2006
Postdeadline Paper Submission Deadline: May 26, 2006, 12:00 p.m. noon EDT (16.00 GMT)
Plan to submit your paper soon!

2006 Participants
Metamaterials 2006

Connect with the most accomplished international scientists, researchers, engineers and business leaders as they shape the future of optics, photonics and laser science.

Conference Co-Chairs

- Azriel Genack, Queens College of CUNY, USA
- Vladimir Shalaev, Purdue Univ., USA

Topics to be considered include:

- Fundamental and applied aspects of waves in structured, periodic and disordered metamaterials and in natural materials as well as those synthesized using traditional techniques of crystal growth, organic and inorganic chemistry.
- Fabrication and photonic properties of metamaterials including photonic and plasmonic band gap materials, negative-index materials and novel composites with unusual optical properties.
- Scattering and imaging in turbulent and static disordered media.
- The statistical nature of wave propagation and localization in random media.
- Partial coherence, coherent backscattering, random lasing, and temporal, spectral and spatial correlation within the speckle pattern.
- Advances in remote sensing, propagation, and active imaging in the atmosphere and in bodies of water, and scattering from aerosols as well as multiple scattering from dilute cold gases.
- The role of diffusing photons and of residual optical coherence in medical and biological tissues.
- Exploration of analogies with the propagation of acoustic, electronic and matter waves and with dynamical localization and chaos.

Don't Miss This Important Event!

"The meeting on Photonic Metamaterials: from Random to Periodic aims to capture the excitement of research on the rapidly growing number of optical phenomena in newly structured and disordered materials fashioned from subwavelength elements. The rapid advance of materials
science makes it possible to design materials with tailored optical characteristics that will provide the basis for emerging photonic technologies."

– Azriel Genack,
Conference Co-Chair
Technical Program Committee

Organizing Committee

- Azriel Genack, Queens College of CUNY, USA, Co-chair
- Vladimir Shalaev, Purdue Univ., USA, Co-chair

Program Committee

- Carlo W. J. Beenakker, Univ. of Leiden, Netherlands
- Hui Cao, Northwestern Univ., USA
- Yeshaiyahu Fainman, Univ. of California at San Diego, USA
- Satoshi Kawata, Osaka Univ., Japan
- Ad Lagendijk, Univ. of Twente, Netherlands
- Evgenii Narimanov, Princeton Univ., USA
- John Pendry, Imperial College, UK
- David J. Pine, New York Univ., USA
- Ping Sheng, Univ. of Science and Technology, Hong Kong
- John Sipe, Univ. of Toronto, Canada
- Bart A. van Tiggelen, CNRS/Univ. of Joseph Fourier, France
- Yuri Vlasov, IBM, USA
- Arjun Yodh, Univ. of Pennsylvania, USA
About Photonic Metamaterials: from Random to Periodic

The development of the full potential of photonics, with revolutionary influence in many areas of science, technology and everyday life, strongly depends on the availability of advanced materials. However, the physical and optical properties of multiple-phase engineered photonic materials, or photonic metamaterials, remain to a large degree undiscovered and unutilized. Photonic metamaterials are expected to open a gateway to unprecedented electromagnetic properties and functionality unattainable from naturally existing materials. The structural units of metamaterials can be tailored in shape and size; the composition and morphology can be artificially tuned, and inclusions can be designed and placed at desired locations. At the same time, the clarification of challenging questions regarding optical propagation in natural materials and in materials synthesized using traditional techniques of crystal growth, organic and inorganic chemistry can lead to enhanced imaging and communication, control over the natural environment, and a deeper understanding of propagation of other classical and quantum waves. This meeting focuses on advancing our understanding of the electromagnetic properties of both novel photonic metamaterials and complex natural media and considers a broad range of structures, from disordered to periodic.

Meeting Topics

This meeting will feature presentations on timely and exciting topics within the scope of the Topical Group on Waves in Random and Periodic Media. The meeting will consider fundamental and applied aspects of waves in structured, periodic and disordered metamaterials and in natural materials as well as those synthesized using traditional techniques of crystal growth, organic and inorganic chemistry. The meeting will discuss the fabrication and photonic properties of metamaterials including photonic and plasmonic band gap materials, negative-index materials, and novel composites with unusual optical properties. These materials can provide subwavelength focusing of light and precise light guiding within micro- and nano-fabricated structures. They afford control of spontaneous emission and lasing in fabricated and self-assembled structures. The meeting will also deal with scattering and imaging in turbulent and static disordered media. The meeting will treat the statistical nature of wave propagation and localization in random media. Partial coherence, coherent backscattering, random lasing, and temporal, spectral and spatial correlation within the speckle pattern will also be discussed. Advances in remote sensing, propagation, and active imaging in the atmosphere and in bodies of water, and scattering from aerosols as well as multiple scattering from dilute cold gases will be of interest. The role of diffusing photons and of residual optical coherence in medical and biological tissues will be considered as well. Because of the strong parallels between electromagnetic radiation and other classical as well as quantum waves, the meeting will explore analogies with the propagation of acoustic, electronic and matter waves and with dynamical localization and chaos.
Photonic Metamaterials Invited Speakers

Metamaterials I: Superlens and Optical Magnetism

MA1, Metamaterials - An Overview, John Pendry; Imperial College, UK.

MA2, Plasmonic MetaMaterials and Optical Super Lens, Xiang Zhang; Univ. of California at Los Angeles, USA.

Localization and Dynamics of Light in Random Media

MB1, The Path of Light in Random Media, Ad Lagendijk; FOM Inst. for Atomic and Molecular Physics, The Netherlands.

MB2, In vivo Tissue Measurements Combining Diffuse Near-Infrared Absorption and Correlation Spectroscopies, Arjun Yodh; Univ. of Pennsylvania, USA.

Photonics Crystals I

MC1, New Directions in Optical Lithography and Functional Architectures, Sajeev John; Univ. of Toronto, Canada.

MC2, Manipulation of Photons Based on Various Engineering in Photonic Crystals, Susumu Noda; Kyoto Univ., Japan.

Plasmonics I: Imaging and Cloaking


TuA2, Engineering Materials with Extreme Optical Properties, Javier Garcia de Abajo; Ctr. Mixto CSIC-UPV/EHU, Spain.

Photonic Crystals II: Negative Refraction and Imaging

TuB1, To Be Announced, Yurii Vlasov; IBM, T. J. Watson Res. Ctr., USA.

TuB2, Photonic Crystal-Assisted Light Extraction from a Colloidal Quantum Dots/GaN Hybrid Structure, Frédéric Diana, Pierre Petroff; Univ. of California at Santa Barbara, USA.

Negative-Index Materials, Super-Resolution and Nonlinear Optics

TuC1, Super-Resolution Imaging and Performance Optimisation for Single- and Multi-Layer Silver Superlenses, Richard J. Blaikie; Univ. of Canterbury, New Zealand.
TuC2, **Optical "Hyperspace": Negative Refractive Index and Subwavelength Imaging in Anisotropic Media**, Evgenii Narimanov, Leonid Alekseyev; Princeton Univ., USA.

**Localized and Diffusive EM Modes**

WA1, **Quasimodal Decomposition of the Spatially Extended Field within a Nominally Localized 1D Open Random Waveguide**, Patrick H. Sebbah$^{1,2}$, B. Hu$^1$, J. M. Klosner$^2$, A. Z. Genack$^2$; $^1$CNRS, France, $^2$Queens College of CUNY, USA.

**Plasmonics II: Negative-Index Materials**

WB3, **Microwave and Infrared Transmission through Normally Opaque Objects**, Ping Sheng; Hong Kong Univ., Hong Kong Special Administrative Region of China.

**Mesoscopic Random Lasers**

WC1, **Lasing in Disordered Photonic Crystals**, Hui Cao, Alexey Yamilov, Xiaohua Wu; Northwestern Univ., USA.

WC2, **Multi-Mode Lasing Theory for Complex or Random Lasers**, A. Douglas Stone, Hakan E. Tureci; Yale Univ., USA.

WC3, **Cold Atoms: Towards Localization and Random Lasing**, Robin Kaiser; CNRS, France.

WC4, **Superradiance and Mesoscopic Transport of Diffusing Photons in Cold Atoms**, Eric Y. Akkermans, Ohad Assaf, Aharon Gero; Technion - Israel Inst. of Technology, Israel.

**Metamaterials III**

ThA1, **Optical Nanoelectronics with Metamaterials**, Nader Engheta; Univ. of Pennsylvania, USA.

ThA6, **Negative Index Materials in GHz and THz Frequencies**, Costas Soukoulis$^{1,2}$, Jiangfeng Zhou$^{1,3}$, Lei Zhang$^{1,3}$, Thomas Koschny$^{1,2}$; $^1$Iowa State Univ., USA, $^2$Inst. of Electronic Structure and Laser – FORTH, and Dept. of Materials Science and Technology, Univ. of Crete, Greece, $^3$Dept. of Electrical and Computer Engineering and Microelectronics Res. Ctr., Iowa State Univ., USA.

**Photonics in Tunable, Scattering and Absorbing Materials**

ThB1, **Light Propagation in Tunable Photonic Materials**, Diederik S. Wiersma; European Lab for Non Linear Spectroscopy and INFM-Matis, Italy.
Closing Session

ThE1, Wrap-Up of Metamaterials — An Overview, Sir John Pendry; Imperial College London, UK.

ThE2, Wrap-Up of the Path of Light in Random Media, Ad Lagendijk; FOM Inst for Atomic & Molecular Physics, The Netherlands.

ThE3, Wrap-Up of New Directions in Optical Lithography and Functional Architectures, Sajeev John; Univ. of Toronto, Canada.

ThE4, From Meta I to Meta II, Azriel Z. Genack, Vladimir Shalaev; ¹Dept. of Physics, Queens College of the City Univ. of New York, USA, ²School of Electrical and Computer Engineering, Purdue Univ., USA.
Publications

Conference Program

The *Conference Program* will be available on the web in May 2006. Authors submitting papers, past meeting participants and current committee members will be notified by email when the *Conference Program* is available.

Technical Digest

The *META Technical Digest* on CD-ROM will contain PDFs of paper summaries presented during the meeting as they were submitted by the authors; the *Technical Digest* will be produced only on CD. At the meeting, each registrant will receive a copy of the Technical Digest on CD-ROM.
Exhibitors

Topical Meeting:  
June 5 – June 8, 2006

Tabletop Exhibit:  
June 5 – June 7, 2006

Photonic Metamaterials 2006 Exhibit Space Reservation Contract

Photonic Metamaterials 2006 Exhibit Space Reservation Contract (PDF, 120KB)

Note: You need Adobe Acrobat to view the PDF files above. If you do not already have this software, you can [download Adobe Acrobat for free](https://get.adobe.com/reader/) from Adobe's web site.

Tabletop exhibit space will be $940 for Corporate Members and $990 for non-members and will include:

- One complimentary registration list
- One complimentary technical registration and two exhibit personnel registrations
- One copy of the meeting's proceedings

If you have questions about exhibiting at this topical meeting, please contact our exhibit sales staff at 202.416.1957 or [exhibitsales@osa.org](mailto:exhibitsales@osa.org).

Sponsorship Opportunities at Photonic Metamaterials 2006

Increase your company's visibility among qualified attendees with a sponsorship at the event.

Current Photonic Metamaterials Sponsorship Opportunities include:

- Coffee Break Sponsorships
- Reception Sponsorships
- Attendee Tote Bag Sponsorship
- Registration Material Inserts
- Advertising Signage Placements

Plus other customizable promotional opportunities

To find out more about one of the sponsorship opportunities listed above or to discuss a customized promotional package or sponsorship, please contact Melissa Russell at 202.416.1957 or email [exhibitsales@osa.org](mailto:exhibitsales@osa.org).
## Agenda of Sessions

### Monday, June 5, 2006

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<td>7:00 a.m.–12:45 p.m.</td>
<td>Registration</td>
<td>Royal Palmer Foyer</td>
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<tr>
<td>8:00 a.m.–10:00 a.m.</td>
<td>MA • Metamaterials I: Superlens and Optical Magnetism</td>
<td>Royal Palm</td>
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<tr>
<td>10:00 a.m.–10:30 a.m.</td>
<td>Coffee Break</td>
<td>Bonds Cay</td>
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<tr>
<td>10:30 a.m.–12:45 p.m.</td>
<td>MB • Localization and Dynamics of Light in Random Media</td>
<td>Royal Palm</td>
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<tr>
<td>12:45 p.m.–7:00 p.m.</td>
<td>Afternoon Break (On Your Own)</td>
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<tr>
<td>6:30 p.m.–9:00 p.m.</td>
<td>Registration</td>
<td>Royal Palmer Foyer</td>
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<tr>
<td>7:00 p.m.–9:00 p.m.</td>
<td>MC • Photonics Crystals I</td>
<td>Royal Palm</td>
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### Tuesday, June 6, 2006

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<td>7:00 a.m.–12:45 p.m.</td>
<td>Registration</td>
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<tr>
<td>8:00 a.m.–10:00 a.m.</td>
<td>TuA • Plasmonics I: Imaging and Cloaking</td>
<td>Royal Palm</td>
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<tr>
<td>10:00 a.m.–10:30 a.m.</td>
<td>Coffee Break</td>
<td>Bonds Cay</td>
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<tr>
<td>10:30 a.m.–12:45 p.m.</td>
<td>TuB • Photonic Crystals II: Negative Refraction and Imaging</td>
<td>Royal Palm</td>
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<tr>
<td>12:45 p.m.–7:00 p.m.</td>
<td>Afternoon Break (On Your Own)</td>
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<tr>
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<td>Registration</td>
<td>Royal Palmer Foyer</td>
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<tr>
<td>7:00 p.m.–9:00 p.m.</td>
<td>TuC • Negative-Index Materials, Super-Resolution and Nonlinear Optics</td>
<td>Royal Palm</td>
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### Wednesday, June 7, 2006

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<tr>
<td>8:00 a.m.–10:00 a.m.</td>
<td>WA • Localized and Diffusive EM Modes</td>
<td>Royal Palm</td>
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<tr>
<td>10:00 a.m.–10:30 a.m.</td>
<td>Coffee Break</td>
<td>Bonds Cay</td>
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<tr>
<td>10:30 a.m.–12:30 p.m.</td>
<td>WB • Plasmonics II: Negative-Index Materials</td>
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<tr>
<td>12:30 p.m.–2:00 p.m.</td>
<td>Lunch Break (On Your Own)</td>
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<tr>
<td>2:00 p.m.–4:00 p.m.</td>
<td>WC • Mesoscopic Random Lasers</td>
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<tr>
<td>4:00 p.m.–6:00 p.m.</td>
<td>WD • Poster Session I/ Refreshment Break</td>
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<tr>
<td>6:00 p.m.–8:00 p.m.</td>
<td>Conference Reception</td>
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<tr>
<td>7:30 a.m.–6:00 p.m.</td>
<td>Registration</td>
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<tr>
<td>8:00 a.m.–10:00 a.m.</td>
<td>ThA • Metamaterials II</td>
<td>Royal Palm</td>
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<tr>
<td>10:00 a.m.–10:30 a.m.</td>
<td>Coffee Break</td>
<td>Bonds Cay</td>
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<tr>
<td>10:30 a.m.–12:30 p.m.</td>
<td>ThB • Photonics in Tunable, Scattering and Absorbing Materials</td>
<td>Royal Palm</td>
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<tr>
<td>12:30 p.m.–2:00 p.m.</td>
<td>Lunch Break (On Your Own)</td>
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</tr>
<tr>
<td>2:00 p.m.–4:00 p.m.</td>
<td>ThC • Postdeadline Papers</td>
<td>Royal Palm</td>
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<td>4:00 p.m.–6:00 p.m.</td>
<td>ThD • Poster Session II/ Refreshment Break</td>
<td>Bonds Cay</td>
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<tr>
<td>6:00 p.m.–7:30 p.m.</td>
<td>ThE • Closing Session</td>
<td>Royal Palm</td>
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Abstracts

• Sunday, June 4, 2006

Royal Palmer Foyer
2:00 p.m.–6:00 p.m.
Registration Open

• Monday, June 5, 2006

Royal Palmer Foyer
7:00 a.m.–12:45 p.m.
6:30 p.m.–9:00 p.m.
Registration Open

MA • Metamaterials I: Superlens and Optical Magnetism
Royal Palm
8:00 a.m.–10:00 a.m.
MA • Metamaterials I: Superlens and Optical Magnetism
Vladimir M. Shalaev; Purdue Univ., USA, Presider
Richard Hammond; ARL, USA, Presider

MA1 • 8:00 a.m. • Grand Talk
Metamaterials - An Overview, John Pendry; Imperial College, UK.
Metamaterials owe their electromagnetic properties to their physical structure rather than to their chemical composition, a characteristic they share with photonic crystals.

MA2 • 8:45 a.m. • Invited
Plasmonic MetaMaterials and Optical Super Lens, Xiang Zhang;
Univ. of California at Los Angeles, USA. I'll discuss a few experiments that demonstrated intriguing metamaterials magnetic properties and optical superlens which breaks down so called diffraction limit. I'll also discuss tunable nano plasmonics applications for imaging and bio-sensing.

MA3 • 9:15 a.m.
Negative Refraction in Si-Based 2-Dimensional Slab Photonic Crystal Structures, Won Park1, Ethan Schönbrun1, Qi Wu1, Y. Yamashita2, C. J. Summers2, Mark Tinker3, Yonghao Cui3, Jeong-Bong Lee3; 1Univ. of Colorado, USA, 2Georgia Tech, USA, 3Univ. of Texas at Dallas, USA. Si-based 2-dimensional slab photonic crystal structures were designed to exhibit negative refraction in the near-infrared region. Negative index imaging was experimentally observed in the integrated device structures including in- and out-coupling waveguides.

MA4 • 9:30 a.m.
“Artificial Magnetism” and Low-Loss Negative-Index Metamaterials at Telecommunication Frequencies, Stefan Linden1, Costas M. Soukoulis2, Gunnar Dolling1, Nils Feth1, Christian Enkrich1, Matthias W. Klein1, Martin Wegener1; 1Forschungszentrum Karlsruhe, Germany, 2Ames Lab and Dept. of Physics and Astronomy, Iowa State Univ., USA, 3Univ. Karlsruhe, Germany. We present metamaterials featuring “artificial magnetism” at telecommunication frequencies. The combination of cut-wire pairs as “magnetic atoms” and a diluted metal yields a negative refractive index at 1.4 μm wavelength, with a transmittance exceeding 50%.

MA5 • 9:45 a.m.
Spatial Dispersion in Metallic Meta-materials, Gennady Shvets1, Dmitry Korobkin1, Yaroslav A. Urzhumov1, Michael Shapiro1; 1Univ. of Texas at Austin, USA, 2MIT, USA. We investigate spatial dispersion in periodic meta-materials and its implication for NIMs. Three metamaterials are investigated for spatial dispersion: 2-D arrays of nanorods, nanoholes in a SiC membrane (experiment), and 3-D metallic mesh.

Bonds Cay
10:00 a.m.–10:30 a.m.
Coffee Break

MB • Localization and Dynamics of Light in Random Media
Royal Palm
10:30 a.m.–12:45 p.m.
MB • Localization and Dynamics of Light in Random Media
Azriel Z. Genack; Dept. of Physics, Queens College of the City Univ. of New York, USA, Presider
Ping Sheng; Hong Kong Univ., Hong Kong, Presider

MB1 • 10:30 a.m. • Grand Talk
The Path of Light in Random Media, Ad Lagendijk; FOM Inst. for Atomic and Molecular Physics, The Netherlands. New ideas, new materials and new experiments have led to an ever growing understanding of propagation of light in random media. We will shortly review the modern developments and lighten some of the new directions.

MB2 • 11:15 a.m. • Invited
In vivo Tissue Measurements Combining Diffuse Near-Infrared Absorption and Correlation Spectroscopies, Arjun Yodh; Univ. of Pennsylvania, USA. I will describe experiments probing tissue hemodynamics. Diffuse photon density waves measure blood oxygenation and total hemoglobin concentration, and diffusing temporal correlation functions measure tissue blood flow. The combination is sensitive to tissue oxygen metabolism.

MB3 • 11:45 a.m.
Dynamics of Photon Localization, Andrey A. Chabanov1, Azriel Z. Genack2; 1Univ. of Texas at San Antonio, USA, 2Queens College of the City Univ. of New York, USA. Steep fall-off of leakage rate of electromagnetic waves with photon transit time as well as rise of fluctuations and correlation are observed in localized samples and compared to models of transport of localized waves.

MB4 • 12:00 p.m.
Observation of the Critical Regime Near Anderson Localization of Light, Christof M. Aegeyer, Martin Störzer, Peter Gross, Georg Maret; Univ. Konstanz, Germany. In this paper we present time resolved measurements of optical transmission, which show clear deviations from classical diffusion. These deviations increase with increasing turbidity, providing experimental evidence for the onset of Anderson localization of light.

MB5 • 12:15 p.m.
Self-Consistent Theory of Anderson Localization in Open Random Media, Sergey E. Skupinov1,2; Bart A. van Tiggeelen1; ‘Ctr. Natl. de la Recherche Scientifique, France, 2Univ. Joseph Fourier, France. Self-consistent theory of localization is adapted to open media by introducing a position-dependent renormalized diffusion coefficient. Non-exponential decay of time-dependent transmission and new power-law scaling of time-dependent reflection are found for random waveguides and slabs.

MB6 • 12:30 p.m.
Scaling Behavior of Classical Wave Transport at the Mobility Edge, Zhao-Qing Zhang, Sai-Kit Cheung; Dept of Physics, Hong Kong Univ. of Science and Technology, Hong Kong Special Administrative Region of China. Scaling behavior of classical wave transport at the mobility edge can be different from that of electron. For slab geometry, the transmission is shown to scale like ln(L/l), different from 1/L obtained for electrons.

MC1 • 7:00 p.m. • Grand Talk
New Directions in Optical Lithography and Functional Architectures, Sajeev John; Univ. of Toronto, Canada. I discuss the utility of 3D PBG materials for light localization based integrated optics, the novel effects of frequency selective control of spontaneous emission, and a new method for microfabrication called “optical phase mask lithography”.

MC2 • 7:45 p.m. • Invited
Manipulation of Photons Based on Various Engineering in Photonic Crystals, Sosumu Noda; Kyoto Univ., Japan. Recent progresses and future prospects of manipulation of photons based on bandgap and defect-, band edge-, and band-engineering in photonic crystals will be reviewed. Spontaneous emission control, ultrahigh Q nanocavity, novel lasers, etc, will be discussed.

MC3 • 8:15 p.m.
Three-Dimensional Silicon Photonic Crystals from Polymer Templates: Single versus Double Inversion, Martin Hermatschweiler1, Markus Deubel1, Martin Wegener1, Fabian Pérez-Willard1, Nicolas Tétreault1, Geoffrey A. Ozin1, Georg von Freymann2, 1Inst. für Angewandte Physik, Univ. Karlsruhe, Germany, 2DFG-Ctr. for Functional Nanostructures (CFN), Univ. Karlsruhe, Germany, 3Dept. of Chemistry, Univ. of Toronto, Canada, 4Inst. für Nanotechnologie, Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft, Germany. We present recent progress in converting polymer templates into three-dimensional silicon photonic crystals by using double (single) inversion. This has led to woodpiles (inverse woodpiles) with improved structural and optical quality.

MC4 • 8:30 p.m.
Plasmonic Resonances in Photonic Crystal Fibres with Coated Inclusions, Karrnan Pathmanandavel, Boris T. Kuhlney, Ross C.
propose to use 2D photonic crystal as a substrate in plasmonic devices. Due to strong anisotropy of the substrate, the propagation range of surface plasmon increases as compared to the case of isotropic substrate.

Coffee Break
10:00 a.m.–10:30 a.m.

TuB • Photonic Crystals II: Negative Refraction and Imaging
Royal Palm
10:30 a.m.–12:45 p.m.

TuB1 • 10:30 a.m. ●Invited●
TBA, Yuriy Vlasov; IBM, T. J. Watson Res. Ctr., USA.

TuB2 • 11:00 a.m. ●Invited●
Photonic Crystal-Assisted Light Extraction from a Colloidal Quantum Dots/GaN Hybrid Structure, Frédéric Diana, Pierre Petroff, Univ. of California at Santa Barbara, USA. In this presentation, we will briefly introduce colloidal QDs structure and optical properties, explain the process of light conversion in GaN-based LEDs, including phosphors or colloidal QDs, and highlight the main causes of losses of light, emitted by both internal sources (usually InGaN QWs) and external ones (phosphors or QDs).

TuB3 • 11:30 a.m.
Light Diffraction in Nanoshell Colloidal Metal-Dielectric Photonic Crystals, Sergei G. Romanov1, Igor E. Protsenko1, Clivia M. Sotomayor Torres1, Andrei Suschev1, Dayang Wang2, Frank Caruso3; *Tyndall Natl. Inst., Univ. College Cork, Ireland, 2Univ. of Munich, Germany, 3Max Plank Inst. of Colloids and Interfaces, Germany, 4Univ. of Melbourne, Australia. Incorporation of gold nanoparticles in 3-dimensional photonic crystals has been used to change the dispersion of optical eigenmodes. A polariton band has been observed at the overlap of diffraction and localised surface plasmon bands.

TuB4 • 11:45 a.m.
Infrared Antenna Using a Photonic Crystal Slab, Marine Laroche, Rémi Carminati, Jean-Jacques Greffet; Ecole Centrale Paris, France. We show that a photonic crystal film can emit coherent thermal radiation. We demonstrate the key role of leaky waves existing at the interface air-photonic crystal.

TuB5 • 12:00 p.m.
Negative Refraction, Imaging, Beam Collimation and Subwavelength Concentration in Photonic Crystals, Juan Luis Garcia-Pomar, Manuel Nieto-Vesperinas; Inst. de Ciencia de Materiales de Madrid, Consejo Superior de Investigaciones Científicas, Spain. We calculate imaging through negative refraction, as well as collimation and subwavelength beam concentration, of high index contrast dielectric photonic crystal slabs. Characterization of the transfer function and rigorous requirements for subwavelength imaging are given.

TuB6 • 12:15 p.m.
Sub-Wavelength Imaging at Optical Frequencies Using a Periodic Layered Metal-Dielectric Structure Operating in the Canalization Regime, Pavel A. Belov, Yang Hao; Queen Mary, Univ. of London, UK. Imaging with sub-wavelength resolution using a periodic metal-dielectric layered structure is demonstrated. The structure operates in canalization regime as a transmission device and it does not involve negative refraction and amplification of evanescent modes.

TuB7 • 12:30 p.m.
Compact Left-Handed Metamaterial Based on Double-Layer Planar Dielectric Strip Arrays, Kaan Gauen, Deniz Caliskan, Ekin Ozbay; Bilkent Univ., Turkey. The existence of a left-handed transmission peak of a metamaterial consisting of double-layer planar dielectric strip arrays at 15 GHz is demonstrated. This design is very suitable to submicron scales required at communication wavelengths.

TuC • Negative-Index Materials, Super-Resolution and Nonlinear Optics
Royal Palm
7:00 p.m.—9:00 p.m.
TuC • Negative-Index Materials, Super-Resolution and Nonlinear Optics
John Pendry; Imperial College, UK, Presider
Harald Giessen; Univ. of Bonn, Germany, Presider

TuC1 • 7:00 p.m. •Invited
Super-Resolution Imaging and Performance Optimisation for Single- and Multi-Layer Silver Superlenses, Richard J. Blakie; Univ. of Canterbury, New Zealand. Super-resolution imaging has been achieved in a lithography environment using both single- and multi-layer silver superlenses. The performance of these systems is compared here, and analytical and simulation methods are used to optimise performance.

TuC2 • 7:30 p.m. •Invited
Optical 'Hyperspace': Negative Refractive Index and Subwavelength Imaging in Anisotropic Media, Evgenii Narimano; Leonid Alekseyev; Princeton Univ., USA. We develop a new approach to materials with negative refractive index and subwavelength imaging systems based on anisotropic dielectric constant in planar and cylindrical geometries, leading to low losses and high tolerance to fabrication imperfections.

TuC3 • 8:00 p.m.
Optical Negative-Index Metamaterials: From Low to No Loss, Vladimir M. Shalaev, T. A. Klar, V. P. Drachev, A. V. Kildishev; Purdue Univ., USA. Practical optical negative index materials based on coupled plasmon resonances must overcome reflection and absorption. Simulations show that matched impedance and compensated losses due to optimized design and gain material lead to 100% transmission.

TuC4 • 8:15 p.m.
Second-Harmonic Generation and Parametric Amplification in Negative-Index Metamaterials, Alexander K. Popov; Vladimir M. Shalaev; Univ. of Wisconsin at Stevens Point, USA; Purdue Univ., USA. Extraordinary nonlinear-optical properties originating from contra-directed wave vector and Poynting vector are investigated. The feasibility of light-controlled transparency, cavityless oscillation and generation of counter-propagating entangled right- and left-handed photons is shown.

TuC5 • 8:30 p.m.
Optical Experiments on Second-Harmonic Generation with Metamaterials Composed of Split-Ring Resonators, Matthias W. Klein; Christian Enkrich; Martin Wegener; Jens Förstner; Jerome V. Moloney; Walter Hoyer; Tineke Stroucken; Torsten Meier; Stephan W. Koch; Stefan Linden; Univ. Karlsruhe (TH), Germany; Univ. of Arizona, USA; Univ. Marburg, Germany; Forschungszentrum Karlsruhe, Germany. We study optical second-harmonic generation from planar arrays of magnetic split-ring resonators at 1.5 microns resonance wavelength. We obtain by far the largest signals when exciting the magnetic-dipole resonance.

TuC6 • 8:45 p.m.
Towards a Negative Index Material Using Pairs of Nanowires, Frank Garve; Carsten Rockstuhl; Christoph Etrich; Uwe Hübner; Ulf Bauerschäfer; Frank Setzpfandt; Markus Augustin; Arkadi Chipouline; Thomas Pertsch; Falk Lederer; Inst. for Physical High Technology, Germany; Friedrich-Schiller Univ., Germany; GmU, Germany. By controlling the distance between parallel nanowires the electric and magnetic resonances of this structure are forced to spectrally coincide. Measurements of amplitude and phase of fabricated samples are provided together with theoretical results.
Electromagnetic Wave Localization in 3D Fractal Structures, Yoshinari Mişanoto1, Yasuake Nakahata1, Satoshi Kirihara2, Mitsuo Wada Takeda2, Katsuya Honda1; 1Joining and Welding Res. Inst., Osaka Univ., Japan, 2Faculty of Science, Shinshu Univ., Japan. Dielectric 3D fractals were fabricated by stereolithography. Transmission and right angle scattering spectra of microwave showed the localizations in GHz range. The localization frequencies showed good agreements with the calculated ones using the empirical equation.

WA6 • 9:30 a.m.
Transport and Anderson Localization in 2-Dimensional Photonic Lattices, Tal Schwartz, Guy Bartal, Shmuel Fishman, Mordechai Segev; Technion, Israel. We present a new approach for studying localization effects in 2-dimensional disordered lattices in linear and nonlinear regimes. We demonstrate experimentally diffusive transport and show that our method can provide direct observation of Anderson Localization.

WA7 • 9:45 a.m.
From Diffusive to Coherent Light Propagation in Disordered Nonlinear Fiber Arrays, Thomas Persch1, Arkadi Chipoulaine1, Stefan Nolte1, Falk Lederer1, Ulrich Rüpke2, Jens Kinkelbe1, Kay Schuster1, Hartmut Bartelt1, Ulf Peschel1, Andreas Tümmernann1, Friedrich-Schiller-Univ., Germany, 1Inst. für Physikalische Hochtechnologie e.V., Germany, 2Max-Planck-Forschungszentrum, Optik, Information und Photonik, Germany, 3Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We observe experimentally the transition from diffusive to coherent (ballistic) light propagation in arrays of mutually coupled optical fibers with an adjustable degree of disorder. Nonlinearity causes mobility and localization for the two respective cases.

Bonds Cay
10:00 a.m.–10:30 a.m.
Coffee Break

WA1 • 8:00 a.m. • Invited
Quasimodal Decomposition of the Spatially Extended Field within a Nominally Localized 1D Random Waveguide, Patrick H. Sebbah1,2, B. Hu1, J. M. Klosner1, A. Z. Genack1; 1CNRS, France, 2Queens College of CUNY, USA. The microwave field is measured inside a random waveguide to reveal multiple peaks in space whenever spectral features are not Lorentzian. The wave is then decomposed into underlying Lorentzian quasimodes which dominate transmission.

WA2 • 8:30 a.m.
Optical Necklace States in Anderson Localized 1D Systems, Jacopo Bertolotti1, Stefano Gottardo1, Riccardo Sapienza1, Diederik S. Wiersma1, Mher Gulhiyan1, Lorenzo Pavesi2, Matteo Galli3, Lucio C. Andreani3; 1European Lab for Nonlinear Spectroscopy and INFM-Matis, Italy, 2Dept. of Physics, Univ. of Trento, Italy, 3INFN-Dept. di Fisica, Univ. of Pavia, Italy. We report on the observation of nonlocalized modes, known as necklace states, in Anderson localized multilayers with positional disorder. Multiple resonant tunnelling transport, characteristic of these modes, was studied both through time-resolved and phase-resolved measurements.

WA3 • 8:45 a.m.
Coexistence of Localized and Delocalized Surface Plasmon Modes in Semicontinuous Metal-Dielectric Films, Katya Gan1, Dentcho Genov1, Andrey Sarychev1, Heeso Noh1, Vladimir M. Shalaev2, Charles Ying3, Xiang Zhang1, Hui Cao1; 1Northwestern Univ., USA, 2Univ. of California at Berkeley, USA, 3Ethereonics Inc., USA, 4Purdue Univ., USA, 5Natl. Inst. of Standards and Technology, USA. Detailed studies of the near-field intensity statistics in semicontinuous metal films provide the first experimental evidence for the coexistence of localized and delocalized surface plasmon modes in metallic random systems.

WA4 • 9:00 a.m.
Light Enhancement and Formation of Photonic Band Gaps in Aperiodic Waveguide Structures, Marianne Hiltunen1,2, Luca Dal Negro1, Ning-Ning Feng1, Lionel C. Kimerling1, Jürgen Michel1; 1MIT Dept. of Materials Science and Engineering, USA, 2Technical Res. Ctr. of Finland, Finland. Novel design of complex waveguide structures that guide light due to the excitation of multiple resonant transmission states induced by aperiodic Thue-Morse environment is presented. We illustrate bandgaps and localization states formed into these structures.

WA5 • 9:15 a.m.

WB1 • 10:30 a.m.
Metal-Dielectric Composites as Materials for Nonlinear Phase Accumulation, Nick N. Lepeshkin1, Aaron Schweinsberg2, Giovanni Piredda2, Robert W. Boyd1; 1San Francisco State Univ., USA, 2Inst. of Optics, Univ. of Rochester, USA. We discuss whether multi-layer metal-dielectric composites can be utilized as materials for efficient nonlinear phase accumulation. We present our experimental results and compare them with the existing numerical models.

WB2 • 10:45 a.m.
Extraordinary Light Transmission through Quasicrystal Arrays of Holes in a Metal Film, F. Javier Garcia de Abajo1, Yifang Chen1, Vassili A. Fedotov1, Nikitas Papasimakis1, Alexander S. Schwanecke1, Nikolay I. Zheludev1; 1Ctr. Mixto CSIC-UPV/EHU, Spain, 2Central Microstructure Facility, Rutherford Appleton Lab, UK, 3EPSRC NanoPhotonics Portfolio Ctr., School of Physics and Astronomy, Univ. of Southampton, UK. We report on the first observation of extraordinary transmission
exhibited by arrays of holes arranged in a 2D quasicrystal in both microwave and optical parts of the spectrum, indicating a non-plasmon nature of the effect.

WB3 • 11:00 a.m. • Invited

Microwave and Infrared Transmission through Normally Opaque Objects, Ping Sheng; Hong Kong Univ., Hong Kong Special Administrative Region of China. Metallic fractals are known to possess localized electromagnetic resonances. The log-periodic localized resonances on H-fractals are shown to induce micro- and infrared wave transparency through normally opaque objects. This is illustrated in three different contexts.

WB4 • 11:15 a.m.

Electromagnetic Field Enhancement at Electrochemical Interface Due to Surface Defects on a Metallic Electrode, Antonio Mandatoni1, Emanuele Castagna2, Vittorio Violante1, Concita Sibilia1, Mario Bertolotti1; 1Dept. di Energetica, Univ. di Roma, Italy, 2ENEA sulla Fissione, Italy. Strong electromagnetic field localization can be obtained at the electrode/electrolyte interface of dielectric inclusions in a metal foil. The enhancement is driven by the strong electrostatic field present close to the metal surface.

WB5 • 11:30 a.m.

Tuning Localized Plasmons in Nanostructured Metamaterials for Surface-Enhanced Raman Scattering Applications, Jeremy J. Baumberg1, Nicolas M. B. Perney1, Tim Kelf1, Robin Cole1, Yoshihiro Sugawara2, Mandoudou E. Abdelsalam1, Susan Contra1, Andrei E. Russell1, Philip N. Bartlett1, Majd E. Zoorob2, Martin D. B. Charlton1, Caterina M. Netti1; 1Univ. of Southampton, UK, 2Mesophotonics Ltd, UK. Reflectivity measurements of gold nanostructures graded in pitch and aperture size allow investigation of localized plasmons. A simple model confirmed by simulations explains the plasmon resonances. Such arrays demonstrate highly unusual and enhanced Raman scattering.

WB6 • 11:45 a.m.

On the Non-Local Character of the Electromagnetic Response of Colloidal Systems, Ruben G. Barrera, Augusto Garcia-Valenzuela; Univ. Nacional Autónoma de México, Mexico. We show the non-local nature (spatial dispersion) of the effective electromagnetic response of a colloidal system. We derive closed expressions and display numerical results for both, the effective non-local electric permittivity and the magnetic susceptibility.

WB7 • 12:00 p.m.

Photo-Induced Voltage across Negative Index Metamaterials, Teruya Ishihara1, Young-Geun Roh1, Yusaburo Segawa2, Nikolay A. Gippius2, Sergei G. Tikhodeev2; 1Frontier Res. System, RIKEN, Japan, 2General Physics Inst., RAS, Russian Federation. Photo-induced voltage across a metallic wire in thin film of negative index material is discussed. Electromagnetic and Poynting vector fields in a perforated metallic bi-layer structure are numerically calculated by the scattering matrix formalism.

WB8 • 12:15 p.m.

All-Angle Negative Refraction for Surface Plasmon Waves Using a Metal-Dielectric-Metal Structure, Hocheol Shin, Shanfui Fan; Stanford Univ., USA. We show all-angle negative refraction of surface plasmon, using a metal-dielectric-metal structure at optical frequencies. Using finite difference time domain simulations, we demonstrate the imaging operation of the structure with realistic material parameters.
WD2
Microscopic Disorder in Metamaterials, Maxim Gorkunov1,2, Sergey A. Greedska1,2, Ilya V. Shadrivov1, Yuri S. Kivshar1; 1Australian Natl. Univ., Australia, 2Inst. of Crystallography, Russian Acad. of Sciences, Russian Federation, 3Ben-Gurion Univ., Israel. We analyze the effect of microscopic disorder on macroscopic properties of composite metamaterials. We demonstrate that 10% deviation in the parameters of resonators leads to substantial suppression of wave propagation in a wide frequency range.

WD3
Second-Harmonic Generation in Left-Handed Metamaterials, Ilya V. Shadrivov1, Maxim Gorkunov1,2, Alexander A. Zhavoronkov1, Yuri S. Kivshar1; 1Australian Natl. Univ., Australia, 2Inst. of Crystallography, Russian Acad. of Sciences, Russian Federation, 3Ben-Gurion Univ., Israel. We study the second-harmonic generation in left-handed metamaterials with a quadratic nonlinear response and demonstrate a novel type of the phase matching. We also suggest binary metamaterials for resonantly enhanced second-harmonic generation.

WD4
Propagation in Absorptive and Dispersive Metamaterials: A Hamiltonian Approach, Navin A. R. Bhat, J. E. Sipe; Dept. of Physics and Inst. for Optical Sciences, Univ. of Toronto, Canada. We present a Hamiltonian approach to pulse propagation in structured materials with absorptive and dispersive response obeying the Kramers-Kronig relations. The method uses effective fields based on the polariton modes of the system.

WD5
Guided Waves in a Bilayer Film Made of Right- and Left-Handed Materials, Cédric Vandenbem1, Starroula Fotiopoulos1, Jean-Paul Vigeron1, Virginie Louisse1,2; 1Facultés Universitaires Notre-Dame de la Paix, Belgium, 2Stanford Univ., USA. We study the guided modes of a composite positive and negative refractive index bilayer film. We find such modes can have very low energy velocities, leading to a cavity-like behavior.

WD6
Surface Plasmon Resonance in a Metallic Pillar Array on a Metallic Substrate in the Terahertz Frequency Region, Takayuki Okamoto1, Satoshi Karasawa1, Hiroaki Minamida2, Hiromasa Itou3, Keishi Ohashi2; 1RIKEN, Japan, 2RIKEN Sendai, Japan, 3Tokyo Univ., Japan, 4NEC Corp., Japan. We propose a new structure, consisting of a two-dimensional metallic pillar array on a metallic substrate, to support surface plasmons in the terahertz frequency region. We experimentally observed a surface plasmon resonance at 1.56 THz.

WD7
Observation of Fast Light in a Microsphere, Kouki Totsuka, Makoto Tomita, Shizuoka Univ., Japan. We observed 4.9 ns negative delay in optical pulse propagation in resonant Whispering Gallery Mode of microsphere. The observed fast light can well be explained by a directional coupling theory on the under coupling condition.

WD8
Dynamical Electric Metamaterial Response at Terahertz Frequencies, Willie J. Padilla1, Antoinette J. Taylor1, Clark Highstrete2, Mark Lee2, Richard D. Averitt2; 1Los Alamos Natl. Lab, USA, 2Sandia Natl. Lab, USA. Utilizing terahertz time domain spectroscopy, we characterized the electromagnetic response of planar Split Ring Resonators fabricated on GaAs. Optical excitation is sufficient to turn off the electric resonance demonstrating the potential of SRR terahertz switches.

WD9
Dispersion and Scattering of Resonant Nanoparticle Chains, A. Femius Koenderink, René de Waade, Albert Polman; FOM Inst. for Atomic and Molecular Physics, The Netherlands. Coupled resonant nanoparticles may help to realize subwavelength control over photons. We claim that metal nanoparticle chains show an unexpected polarization splitting in the dispersion relation and discuss consequences for scattering and subwavelength optical confinement.

WD10
Light-Wave Guidance through Stratified Photonic Crystal Metamaterials Synthesized by Super-Inductive Layers of Metallic Nano-Stripes, Nikolaos J. Florous, Kunimasa Saitoh, Masanori Koshita; Div. of Media and Network Technologies, Hokkaido Univ., Japan. We theoretically demonstrate the possibility of strong light-wave guidance through a novel class of photonic crystal metamaterial platform entirely synthesized by ultra-low refractive index suspended nano-stripes. Basic waveguiding structures can be realized on the nano-scale.

WD11
Nano Optical Modes of a Gap Structure in a Left-Hand-Metamaterial Waveguide, Noam Kaminsky, Yinon Sature, Meir Orenstein; Technion - Israel Inst. of Technology, Israel. A dielectric gap in a metamaterial is employed for simultaneous transport of right and left hand optical fields. The metamaterial is implemented by elongated nano-metallic inclusions, to generate negative refractive index of the waveguide anisotropy.

WD12
Hetero-Structure Photonic Crystal Demultiplexer Based on Ultra-Low Refractive Index Nano-Wires: Towards Temperature-Insensitive Metamaterial Platforms, Nikolaos J. Florous, Kunimasa Saitoh, Masanori Koshita; Div. of Media and Network Technologies, Hokkaido Univ., Japan. We propose and numerically investigate the thermal-insensitive properties of a novel type of wavelength selective filter based on heterostructure photonic crystals entirely synthesized by ultra-low refractive index metallic nanowires, for efficient demultiplexing of visible frequencies.

WD13
A Possible Route for Left-Handed Meta-Materials Using Ferromagnetic-Metal Nanocomposite Films, Satoshi Tomita1, Haruhiko Yoshiro2, Takanari Kasuwa3, Masayuki Hagiwara2, Chiharu Mitsumata3, Hidemi Nawa1, Ken-ichi Kato1, Akatsuka3; 1Japan Science and Technology Agency, Japan, 2Osaka Univ., Japan, 3Hitachi Metals Ltd., Japan, 4Konan Univ., Japan. Ferromagnetic-metal nanocomposite films as a candidate for left-handed meta-materials in microwave regions were experimentally studied. Electron magnetic resonance study suggests that the film microstructure influences resonance frequency around which the negative permeability may be obtained.

WD14
Perfect Transparency in Opaque Optical Systems, Ivo M. Vellekoop, Allard P. Mosk; Univ. of Twente, The Netherlands. We shape the wavefront of light incident on disordered, multiply scattering systems. Using computer controlled modulators and feedback-based learning algorithms we strive to find the perfectly transparent modes that theory predicts.

Lumped Circuit Model for an Active Right-Handed Medium with Negative Refractive Index, Bertil Nistad, Johannes Skaar; Dept. of Electronics and Telecommunications, Norwegian Univ. of Science and Technology, Norway. Active, right-handed media exist for which the refractive index is negative in a finite bandwidth. We propose a lumped circuit model for such media, based on a resonant transmission line with negative shunt resistance.

Spin-Dependent Ultrafast Optical Nonlinearities in Bragg Spaced Quantum Wells, Wesley J. Johnston1, John P. Prime3, Arthur L. Smirl1, Hyatt M. Gibbs2, Galina Khitrova2; 1Univ. of Iowa, USA, 2Univ. of Arizona, USA. We observe spin-dependent ultrafast blue shifts, transient gain, and the opening of spectral transmission windows in the forbidden gap of the photonic band structure of Bragg-spaced InGaAs/GaAs quantum wells.

Laser Threshold of Mie Resonances, Karen L. van der Molen1, Peter Zijlstra2, Ad Lagendijk2; Allard P. Mosk1; 1Univ. of Twente, The Netherlands, 2FOM Inst. for Atomic and Molecular Physics (AMOLF), The Netherlands. We present work on laser resonances in dielectric spheres. Experimentally, the fluorescence line width of a dye-doped microsphere decreases with increasing pump intensity. Theoretically, we corroborate this observation and derive a new laser threshold criterion.

Magneto-Optical Kerr Effects of Magnetic Garnet Thin Films Including Plasmonic Noble-Metal Nanoparticles, Satoshi Tomita1, Takeshi Kato1, Shigeru Tsunashima1, Satoshi Iwata2, Minoru Fujii2, Shinji Hayashi2; 1Japan Science and Technology Agency, Japan, 2Nagoya Univ., Japan, 3Kobe Univ., Japan. We report an experimental study on magneto-optical (MO) Kerr effects of yttrium iron garnet (YIG) films incorporating plasmonic Au nanoparticles. The results indicate a possible coupling between the MO Kerr effects and localized surface plasmons.

Negative Index Composite Metamaterials as One Dimensional Single Negative Stacks, Alexandra I. Cahuz, Didier Felbacq, David Cassagne; Univ. Montpellier II, France. We show that negative index metamaterials can be realized using one dimensional single negative stacks. Homogenization theory shows that the effective parameters of such structures can become unbounded. We discuss consequences of this remarkable fact.

Role of Localized Waveguide Resonances in the Enhanced Transmission through Periodic Arrays of Subwavelength Holes, Zhichao Ruan, Min Qin; Royal Inst. of Technology (KTH), Sweden. It is shown that the localized waveguide resonance exists in both the perfectly electronic conductivity film and the Au film with subwavelength holes, and plays an important role in the enhanced transmission.

Ring-Shaped Molecules as Split Ring Resonators of a Molecular Metamaterial, Frank Brechteld, Norbert Lindlein, Gerd Leuchs, Ulf Peschel; Inst. of Optics, Information and Photonics, Univ. of Erlangen-Nuremberg, Germany. We analytically analyse the magnetic response of ring shaped molecules. We find that circular symmetry must be broken and that transitions between higher order states have to be enabled to obtain a reasonable magnetic response.

Effective Electromagnetic Properties of Structured Chiral Metamaterials, Ouail Ouchet1, Said Zoughdi1, Alain Bossavit1, Bernadette Miure2; 1Lab de Génie Electrique de Paris-Sudélec, France, 2ESIEE, Lab de Modélisation et Simulation Numérique, France. A novel methodology to evaluate the effective parameters of a three-dimensional lattice of chiral inclusions is presented. The homogenization is based upon mathematical arguments. The finite element technique is used to compute the constitutive parameters.

Conservation of Electromagnetic Momentum and Shear Radiation Forces Exerted on Left-Handed Material Interfaces, Spiillos Rigopoulos; SAIC, USA. A reversal in the parallel-to-the-surface electromagnetic momentum direction occurs at left-handed material interfaces. The parallel-to-the-surface shear force resulting from the imparted change in EM momentum, unique to left-handed interfaces, is computed.

Chemical Route Prepared Magnetic Structure at Infrared Frequencies, Xiao P. Zhao, H. Liu; Dept. of Applied Physics, Northwestern Polytechnical Univ., China. We propose a novel quasi-periodical dendritic model, which can be prepared using chemical electro-deposition method, for the realization of negative permeability. The simulation and experimental results confirmed the magnetic response at infrared frequencies.

Resonances in Light Scattering by Small Magnetic Particles, Brasilio Garcia-Cámara1, Francisco Gonzalez1, Fernando Moreno1, José M. Saiz1, Gorden Videen2; 1Univ. de Cantabria, Spain, 1ARL, USA. Light scattering resonances in small particles are analyzed either exactly or by approximate expressions for the most important Mie coefficients. Materials with different optical properties, including Double Negative (as corresponding to LHM), are considered.

A First Attempt to Assess Marine Particles Composition from Remote Sensing: Exploitation of the POLDER Polarized Radiiances, Hubert Loisel, Lucile Duforet, David Dessailly, Philippe Dubuisson; Univ. du Littoral-Côte d’Opale, France. The particulate backscattering coefficient and the degree of polarization provide a means to study and characterize the nature of suspended marine particles. Here, we show that such information may be retrieved from remote sensing.
WD27
A Novel Metamaterial Structure with High Dielectric Resonators, Jaecen Kim, Anand Gopinath; Univ. of Minnesota, USA. Wave propagation in a novel metamaterial structure with high dielectric resonators embedded periodically in a low dielectric material is simulated. We demonstrate by simulation that this structure without any metal is a double negative material.

WD28
Negative Capacitance Effect in Impedance Spectroscopy, Harry L. Kwok¹, Xingming Wang¹, J. B. Xu¹, L. W. M. Lau¹, ¹Univ. of Victoria, Canada, ²Chinese Univ. of Hong Kong, China. “Universality of Photocurrent Transients” was shown to apply to Alq3 thin films when the real part and the imaginary part of the carrier mobility had the same magnitude. We verify this also applies to CuPc.

WD29
A Grating-Bicoupled Plasmon-Resonant Terahertz Emitter Fabricated with GaAs-Based Heterostructure Metamaterial Systems, Taiichi Otsuji¹, Yahya M. Meziani², Mitsuhiro Hanabe¹, Takuma Ishibashi¹, Tomohiro Uno¹, Eiichi Sano²; ¹Tohoku Univ., Japan, ²Hokkaido Univ., Japan. A grating-bicoupled plasmon-resonant terahertz emitter was fabricated using GaAs-based heterostructure metamaterial systems. Photo-excited electrons, injected to the two-dimensional plasmon cavities, promoted the plasmon instability, resulting in the first observation of terahertz emission at room temperature.

Pavilion
6:00 p.m.–8:30 p.m.
Conference Reception
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| Thursday, June 7, 2006 | Royal Palm Foyer  
7:30 a.m.–6:00 p.m.  
Registration Open |

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| 8:00 a.m.   | ThA • Metamaterials III  
Royal Palm  
8:00 a.m.–10:00 a.m.  
ThA • Metamaterials III  
Evgenii Narimanov; Princeton Univ., USA, President  
Graeme W. Milton; Dept. of Mathematics, USA, President |

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| 8:00 a.m.   | ThA1 • 8:00 a.m.  
Optical Nanoelectronics with Metamaterials, Nader Engheta; Univ. of Pennsylvania, USA. We give an overview of the fundamental properties of optical "lumped" circuit elements and components, utilizing optical metamaterials. We will discuss how these elements can be the building blocks for more complex optical nanoelectronics. |

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| 8:30 a.m.   | ThA2 • 8:30 a.m.  
Subwavelength Imaging by Full 3D Negative Refraction Using a 3D Photonic Crystal, Dennis W. Prather, Zhaolin Lu, Janusz A. Murakowski, Shuyuan Shi, Cailua Chen, Christopher A. Schuetz, Garrett J. Schneider; Univ. of Delaware, USA. A 3D body-centered cubic photonic crystal was designed and fabricated to achieve full 3D negative refraction by dispersion engineering. Three-dimensional subwavelength resolution imaging was experimentally demonstrated using this photonic crystal in a microwave regime. |

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| 8:45 a.m.   | ThA3 • 8:45 a.m.  
Radiative and Nonradiative Decay of Near-Infrared Excitations in Split-Ring Resonator Metamaterials, Harald Giessen1, Thomas Zentgraf, Carsten Rockstuhl1, C. Ettrich, Hongcang Guo, Na Liu, Todd Meyrath1, Heinz Schweizer1, Stefan Kaiser1, Jürgen Kuhl, Falk Lederer2; 1Univ. of Stuttgart, Germany, 2Max Planck Inst. for Solid State Res., Germany, 3Friedrich-Schiller Univ., Germany. The influence of the specific split-ring resonator geometry on the electromagnetic resonances and especially their spectral width is analyzed experimentally and theoretically. Furthermore, we separate radiative and nonradiative contributions to the linewidth of the resonances. |

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| 9:00 a.m.   | ThA4 • 9:00 a.m.  
Observation of Magnetoinductive Waves in Metamaterials, Ilya V. Shadrivov1, Alexander N. Reznik1,2, Alexander A. Zharro1,2, Nina A. Zharro1,2, Yuri S. Kivshar1; 1Australian Natl. Univ., Australia, 2Inst. for Physics of Microstructures, Russian Acad. of Sciences, Russian Federation, 3Inst. of Applied Physics, Russian Acad. of Sciences, Russian Federation. We develop the theory and study experimentally the propagation of linear magnetoinductive waves in composite metamaterials. We present results of the first experimental observation of magnetoinductive waves in one-dimensional arrays of resonators. |

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| 9:15 a.m.   | ThA5 • 9:15 a.m.  
Novel Electric Metamaterials Studied at Terahertz Frequencies, Willie J. Padilla1, Marie T. Aronsson1, Clark Highstreth2, Mark Lee1, Antoinette J. Taylor1, Richard D. Averitt1; 1Los Alamos Natl. Lab, USA, 2Sandia Natl. Lab, USA. We present new designs for metamaterials that exhibit a tailored resonant electrical response, investigated with THz time domain spectroscopy. These electric metamaterials will significantly ease the burden of construction for future negative index metamaterial devices. |

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| 9:30 a.m.   | ThA6 • 9:30 a.m.  
Negative Index Materials in GHz and THz Frequencies, Costas Soukoulis1,2, Jiafeng Zhou1,3, Lei Zhang1,3, Thomas Kочын1,2; 1Iowa State Univ., USA, 2Inst. of Electronic Structure and Laser – FORTH, and Dept. of Materials Science and Technology, Univ. of Crete, Greece, 3Dept. of Electrical and Computer Engineering and Microelectronics Res. Ctr., Iowa State Univ., USA. We present new designs, fabrication and experiments on metamaterials that give a negative index of refraction, with low imaginary part, form GHz to THz frequencies. |

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<td>10:00 a.m.</td>
<td>Coffee Break</td>
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| 10:00 a.m.  | ThB • Photonics in Tunable, Scattering and Absorbing Materials  
Royal Palm  
10:00 a.m.–10:30 a.m.  
Coffee Break |

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| 10:30 a.m.  | ThB • Photonics in Tunable, Scattering and Absorbing Materials  
Ross McPhedran; Univ. of Sydney, Australia, President  
Jean Jacques Greffet; Ecole Centrale Paris, France, President |

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| 10:30 a.m.  | ThB1 • 10:30 a.m.  
Light Propagation in Tunable Photonic Materials, Diederik S. Wiersma; European Lab for Nonlinear Spectroscopy and INFM-Matis, Italy. We will discuss light transport in complex photonic structures like random lasers and photonic crystals. In particular we will focus on tuning and switching via liquid crystal infiltration and discuss various models of random lasing. |

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| 11:00 a.m.  | ThB2 • 11:00 a.m.  
Photon Diffusion Coefficient in Absorbing Random Media, Reni Carminati, Romain Pierrat, Jean-Jacques Greffet; Ecole Centrale Paris, France. We present a derivation of the photon diffusion coefficient in scattering and absorbing (or amplifying) media, valid for both steady-state and time-dependent transport. Our results resolve a recurrent controversy concerning its dependence on absorption. |

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| 11:15 a.m.  | ThB3 • 11:15 a.m.  
Disorder-Induced Resonances in One-Dimensional Lossy Samples: Detection and Characterization, Konstantin Bliokh1, Yuri Bliokh1, Valentin Freilikher, Bing Hu1, John Klosner, Azriel Genack2, Patrick Sebah1; 1Inst. of Radio Astronomy, Ukraine, 2Technion Univ., Israel, 3Bar-Ilan Univ., Israel, 4Queens College of the City Univ. of New York, USA, 5Univ. de Nice, France. Localized states in one-dimensional disordered samples with losses have been observed experimentally and interpreted theoretically. An algorithm is developed of the detecting and characterizing the resonances via measurements of the reflection coefficient. |

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| 11:30 a.m.  | ThB4 • 11:30 a.m.  
Disordered Wave-Guides with Absorption: Transmittance Distribution at the Diffusive-Localized Crossover, Luis S. Froufe-Pérez1, Pedro García-Machales2, Juan José Sáenz1, Pedro A. Serena2; 1Univ. Autónoma de Madrid, Spain, 2Inst. Ciencia de Materiales de Madrid, CSIC, Spain. An analysis, from calculations of a “tight-binding” model, of |
the behavior of transmittances distributions on the diffusive-localize
regimens crossover in ordered wave-guides with absorption is
presented. Findings resemble results found in microwaves-guide
experiments.

ThB5 • 11:45 a.m.
Stochastic Modeling of Coherent Effects in Multiple Scattering,
Vladimir L. Kazmirov, Dmitriy Y. Churmakov, Igor Mglinski;
"St.-Petersburg Inst. of Commerce and Economics, Russian Federation,"
"Cranfield Univ., UK." Based on the iteration procedure of Bethe
Salpeter equation, the Monte Carlo technique is generalized for the
simulation of coherent effects in respect of polarization of the
electromagnetic field of scattered radiation.

ThB6 • 12:00 p.m.
Anisotropic Multiple Scattering of Light, Riccardo Sapienza,
Diederik S. Wiersma, Cecil Chewng, Arjan G. Yodhi, Dominique Delande;
"European Lab for Nonlinear Spectroscopy and INFM-Matis, Italy,"
"Dept. of Physics and Astronomy, Univ. of Pennsylavia, USA,"
"Lab Kastler-Brossel, Univ. Pierre et Marie Curie, France." We report on the first
observation of anisotropy in weak localization of light from ordered
nematic liquid crystals and on vectorial Monte Carlo simulations of
anisotropic multiple scattering and weak localization using anisotropic Rayleigh
scatterers.

ThB7 • 12:15 p.m.
Synchronization of Optical Polarization Conversion and Scattering
in Chiral Fibers, Azriel Z. Genack,1,2; Victor I. Kopp,1 V. M. Churikov,2; J.
Singer,1 N. Chao,3 C. Draper,4 D. Neugrosch;3 "Queens College of CUNY, USA,"
"Chiral Photonics, Inc. USA." Polarization conversion and
scattering are synchronized in birefringent fiber twisted with
nonuniform pitch so that one incident polarization eigenstate is
strongly scattered while the other is freely transmitted. This makes
possible a broadband linear polarizer.

ThC • Postdeadline Papers

Royal Palm
2:00 p.m.–4:00 p.m.
ThC • Postdeadline Papers
ThC • 2:00 p.m.–4:00 p.m.
David A. B. Miller; Stanford Univ., USA, Presider
Douglas Stone; Yale Univ., USA, Presider

Results announced on-site.

ThD2
Probing Minimal Scattering Events in Coherent Backscattering of
Light Using Low-Coherence Induced Dephasing, Young L. Kim,
Prabhakar Pradhan, Harithanan Subramanian, Yang Liu, Min H. Kim,
Vadan Backman; Northwestern Univ., USA. We exploit low spatial
coherence illumination to dephase time-reversed partial waves
outside its finite coherence area, which isolates the minimal
scattering events (i.e., double scattering) from higher order scattering
in coherent backscattering of light.

ThD3
Observation of Discrete Nonlinear X-waves, Yoav Lahini1, Eugene
Frumker1, Yaron Silberberg2, Sotiris Droulias1, Kyriakos Hizanidis1,
Roberto Morandotti2, Demetrius N. Christodoulides2; "Weizmann Inst. of
Science, Israel," "Natl. Technical Univ. of Athens, School of Electrical and
Computer Engineering, Greece," "1Inst. Natl. de la Recherche Scientifique,
Canada," "College of Optics and Photonics, CREOL, Univ. of Central
Florida, USA." We present experimental evidence for the formation of
nonlinear X-waves in AlGaAs waveguide arrays. These results agree
with numerical simulations based on the discrete nonlinear
Schrödinger equation with an appropriate temporal dispersion term.

ThD4
Broken Symmetry in Photonic Crystals: Resonant Zener Tunneling
of Light Waves, Costanza Toninelli, Diederik S. Wiersma, Mher
Ghulinyan, Zeno Gaburro, Lorenzo Pavesi, Claudio J. Oton; "European
Lab for Nonlinear Spectroscopy and INFM-Matis, Italy," "Dept. of Physics,
Univ. of Trento, Italy," "Dept. de Fisica Basica, Univ. of La Laguna, Spain.
We report on the observation of Zener tunnelling of light waves in
spectral and time-resolved transmission measurements, performed
on an optical superlattice of porous silicon with broken translational
symmetry.

ThD5
Metamaterials for Omnidirectional Reflectors and Hollow-Core
Waveguides, Mark Bloomer, Giuseppe D’Aganno, Michael Scalora,
Nadia Mattiucci1,2; "Dept. of the Army, USA," "Universita “RomaTre”
Dept. di Fisica, Italy," "Time Domain Corp., USA." We show that
metamaterials have omnidirectional reflecting properties in the
frequency region between the magnetic plasma frequency and the
electric plasma frequency. These properties are useful for reflectivity
control, low loss mirrors, and hollow-core waveguides.

ThD6
Stretchable Photonic Crystals Based on Polymers, Otto L. J.
Pursiainen1,2; Jeremy J. Baumberg1, Holger Winkler1, Benjamin Viel1,
Tilmann Ruhl1; "Univ. of Southampton, UK," "Merk KGaA, Germany,"
"Deutsches Kunststoff-Institut (DKI), Germany." Novel optical properties
of stretchable polymer-based opals are presented. Nanoparticle
doping strongly enhances the sharpness and depth of transmission
filtering. Angle-dependent chromatic scattering exhibits unusual
dispersion characteristics beyond the Bragg scattering regime.

ThD7
Bandgap Guidance in Two-Dimensional Light-Induced Photonic
Lattices, Xiaocheng Wang1,2, Igor Makasyuk1,2, Zhigang Chen1,2, Jianke
Transport Mean-Free-Path in K2Bi\(_2\)O\(_4\)(MoO\(_4\)) Crystal Powders, Maria Asuncion Illarramendi, Mohamed Al-Saheb, Iben Aramburu, Rolindes Balda, Joaquin Fernández; Univ. del Pais Vasco, Spain. The transport mean-free-paths in K2Bi\(_2\)O\(_4\)(MoO\(_4\)) laser crystal powders were determined by using the diffuse reflectance and transmittance of the powders and the absorption coefficient of the crystal materials. Similar results were obtained from both methods.

**ThD10**

All-Optical Tuning of the Superprism Effect Near Band Edges of Nonlinear Waveguide Arrays, Yaro Lahini, Daniel Mandelik, Yaron Silberberg; Weizmann Inst. of Science, Israel. We investigate experimentally nonlinear effects near the photonic band edges of periodic waveguide arrays. We find that near resonance, nonlinearity results in strong beam shifts due to the high curvature of the diffraction curves.

**ThD11**

Tamm and Shockley Surface States in Photonic Crystal, Natalia Malkova, Cun-Zheng NING; NASA Ames Res. Ctr., USA. The Shockley surface states in photonic crystals are demonstrated for the first time. In crystals with simple unit cell, surface states are shown to be the Tamm-like rather than the Shockley states as commonly believe.

**ThD12**

Spectra of ZnO Random Lasers under Nanosecond Pumping, Mikhail V. Ryzhkov, Valery M. Markushev, Charsis M. Briskina, Hui Cao; Inst. of Radio Engineering and Electronics of RAS, Russian Federation, Dept. of Physics and Astronomy, Northwestern Univ., USA. The study of ZnO random lasing spectra showed that they are significantly different from obtained under picosecond pumping ones. The lines in the spectra are noticeable wider and their positions change from shot to shot.

**ThD13**

Quasiperiodic Photonic Crystals: A Structure between Random and Periodic, Carsten Rockstuhl, Falk Lederer; Inst. of Condensed Matter Theory and Solid State Optics, Germany. The optical response (band gaps, effect of disorder, defect modes) of quasiperiodic crystals made of high-index dielectric cylinders is explained in terms of Mie resonances. Moreover, these studies are extended towards random photonic crystal.

**ThD14**

Selective Modification of Opal Photonic Crystals Using Atomic Layer Deposition, Zachary A. Sechrist, Brian T. Schwartz, Jin H. Lee, Jared A. McCormick, Wounghang Park, Rafael Piestun, Steven M. George; Univ. of Colorado, USA. We report on 3D opal photonic crystal modification by atomic layer deposition (ALD). Alumina ALD was used to coat silica opals with conformal films and hence tune the position and intensity of the Bragg peak.

**ThD15**

The Modelling of Fano Resonances in Photonic Crystal Slabs, Lindsay C. Botten, Ross C. McPhearen, Michael A. Byrne, Ara A. Asatryan, Nicolae A. Nicorovic, Andrew H. Norton, C. Martijn de Sterke; Univ. of Technology, Australia, Univ. of Sydney, Australia. A Bloch mode theory for diffraction of plane waves by planar PC slabs is outlined. The theory provides physical insight into the origin of Fano resonances, allowing a simple pole model to be deduced rigorously.

**ThD16**

Solitary Waves in Photonic Structures: Analytical Solutions of the Nonlinear Kronig-Penney Model, Yannis Kominis, Kyriakos Hizanidis, Ilias Tsepelas, Nikolaos Moshonas, Panagiotis Papagiannis, Nikolaos Efremidis, Sotirios Droulias, Lambros Halastanis, Georgios Papapicou; Natl. Technical Univ. of Athens, Greece. A novel method is presented for the construction of analytical solitary wave solutions of the nonlinear Kronig-Penney model in a photonic structure. The solutions correspond to gap solitons and are obtained under generic conditions.

**ThD17**

Energy Transport by Classical Waves through Multilayers of Diffusing Slabs, Sijmen Gerritsen, Gerrit E. W. Bauer; Kavli Institute of Nanoscience, Delft Univ. of Technology, The Netherlands. We describe the effect of interfaces on classical wave propagation through diffusing layered media. A series resistor model for wave energy transport is introduced and we derive a microscopic expression for the interface resistance.

**ThD18**

Polarization Selective Devices Embedded in Glass Fabricated by Femtosecond Laser Induced Nanogratings, Ariel R. Libertun, Wenjian Cai, Timothy Gerke, Rafael Piestun; Univ. of Colorado, USA. We demonstrate polarization selective devices for visible light operation fabricated in glass by a femtosecond laser. The devices are composed of arrays of micro-waveplates which are tailored by the laser formation of nanogratings in glass.

**ThD19**

A Periodic Structure of Coupled Double Quantum Wells for Significant Light Slowing, Pavel Ginzburg, Meir Orenstein; Technion-Israel Inst. of Technology, Israel. Novel periodic metamaterial, having a unit cell comprised of 2 coupled quantum wells, exhibits unusual refractive index dispersion and is supporting light propagation with low group velocity and absorption cancellation at a very narrow peak.

**ThD20**

The (Quasi) Natural Mode Description of the Scattering Process by Dispersive Photonic Crystals., Bernhard J. Hoenders; Univ. of Groningen, Inst. for Theoretical Physics and Materials Science Ctr., The Netherlands. A scattering theory for finite photonic crystals in terms of the natural modes of the scatterer is developed. This theory generalizes the classical bilinear expansions of the propagator to a bilinear expansion into natural modes.

**ThD21**

Threshold of Random Lasers with Incoherent Feedback, Remi Carminati, Romain Pierrat; Ecole Centrale Paris, France. We study random lasers with incoherent feedback using the Radiative Transfer Equation and rate equations. Dynamics and spectral signatures of
the lasing threshold are observed that are not connected to Anderson localization.

**ThD22**

*Extraordinary Optical Reflection and Resonant Absorption from Sub-Wavelength Cylinder Arrays*, Marine Larochet, Juan José Saenz, Raquel Gómez-Medina; Univ. Autonoma de Madrid, Spain, 2Donostia Intl. Physics Ctr. (DIPC), Spain. An analytical multiple scattering study of the reflectance and absorption of a periodic array of sub-wavelength cylinders is presented. The conditions for perfect reflection and resonant absorption are discussed.

**ThD23**

*Extraordinary Transmission of Terahertz Electromagnetic Waves through 2-Dimensional Metallic Photonic Crystal*, Yosuke Mineava, Taishi Nishihara, Koshin Hosoki, Kōichiro Tanaka; Dept. of Physics, Kyoto Univ., Japan. We demonstrate extraordinary THz transmission through free-standing metal wire meshes using THz time-domain spectroscopy measurement. We treat the meshes as metamaterial slabs and show that the extraordinary transmission is occurred at the reduced plasma frequency.

**ThD24**

*Polarization Dependent Functionality of Optical Elements Based on (Quasi) Periodic Two-Dimensional Structures*, Eugen Foca, Juergen Carstensen, Helmut Foell, Vladimir V. Sergentse, Ion M. Tiginyanu, Frank Daschner, Reinhard Knoechel; Christian-Albrechts- Univ. of Kiel, Germany, 2Inst. of Applied Physics, Acad. of Sciences of Moldova, Republic of Moldova, 3Microwave Lab, Christian-Albrechts-Univ. of Kiel, Germany. Quasi-periodic miniaturized structures are explored for optical elements and measured in the microwave spectral range. Enticing focusing properties and real potential for radiation manipulation are demonstrated. The polarization dependent operation of the device is characterized.

**ThD25**

*Second Harmonic Generation in KDP Micro-Powder by Femtosecond Pulses*, Ibn Aramburu, Joaquín Fernández, Rolíndes Balda, Maria Asuncion Ilarramendi; Univ. del País Vasco, Spain. Second harmonic generation with ultrahigh intensity femtosecond pulses has been studied experimentally and theoretically in KDP micro-powder. The second harmonic pulse intensity shows a quadratic dependence on the fundamental intensity with a noticeable spectral broadening.

**ThD26**

*Ultrafast Dynamics of Surface Plasmon Polaritons in a Subwavelength Nanohole Array*, Tigran V. Shabbazyan, Arman S. Kirakosyan, Minghong Tong, Valy Vardany; Jackson State Univ., USA, 2Dept. of Physics, Univ. of Utah, USA. The ultrafast dynamics of surface plasmon polaritons generated on the surfaces of an Al film perforated with 2D subwavelength hole array is studied by the pump-probe correlation spectroscopy.

**ThD27**

*The Effect of Disorder on Photonic Crystal Pipe Lattices*, Daniel R. Solli; 1Univ. of California at Berkeley, USA, 2Univ. Federal de Alagoas, Brazil. Using finite-element simulations, we study the effect of imperfections in two-dimensional photonic crystals of pipes. We discuss the stability of certain special transmission properties of pipe lattices against disorder.

**ThD28**

*Relationship of Speckle Statistics in Single Configuration and in Ensemble of Random Configurations*, Sheng Zhang, Bing Hui, Azriel Z. Genack, Andrey A. Chabanov, Patrick Sebbah; 1Univ. of Texas at San Antonio, USA, 2Univ. of New York, USA, 3CNRS and Univ. de Nice-Sophia Antipolis, France. The equivalence of localization in the time domain and mesoscopic fluctuations in the frequency domain is demonstrated in the comparison of measurements of the statistics of microwave field in single configurations and in random ensembles.