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RPPR Final Report

as of 03-Jan-2019

Agency Code:

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Agreement Number: W911NF-18-1-0174

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Report Date: 09-Feb-2019

Date Received: 09-Nov-2018

Final Report for Period Beginning 14-May-2018 and Ending 09-Nov-2018

Title: Conference Support for the 2018 Imaging Systems and Applications (IS) Topical Meeting

Begin Performance Period: 14-May-2018

End Performance Period: 09-Nov-2018

Report Term: 0-Other

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Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees:

STEM Participants: 14

Major Goals: 1. Create a program that focuses on cutting-edge research and innovative new tools and techniques to increase fundamental knowledge in the field of imaging and corresponding technologies.

2. Gather distinguished experts in imaging research and applications, foster in-depth exploration of topics, and facilitate one-on-one interactions through the meeting organization.

3. Share groundbreaking research with colleagues, luminaries and industry leaders through peer-reviewed papers that ensure high-quality presentations on important, timely and emerging topics to discuss technology development and its applications.

4. Engage with industry and offer opportunities to meet with exhibitors during the exhibit and industry sessions.

5. Provide opportunities for students and early career professionals to present their work and interact with experts in the field, as well as to participate in professional development events.

6. Provide support for attendees with limited resources to travel and attend the meeting to learn from and interact with leaders in the field.

Accomplishments: Imaging Systems and Applications (IS) Meeting was one of the ten topical meetings at the OSA Imaging and Applied Optics Congress (Imaging) that addressed the challenges faced by the imaging community. IS brought together experts from many different scientific and engineering disciplines who contribute to the design and integration of optics, sensors, digital processing and displays in imaging systems. IS captures the state-of-the-art in unique light gathering optics, image sensor architectures and technology, on and off chip digital image processing, and methods for compression, storage, transmission, and utilization. The meeting discussed the following topics:

Applications of military, industrial, medical and consumer imaging with special sessions on:

- Wearable sensors and displays
- 3-D imaging - capture methods and displays
- Imaging for autonomous vehicles
- Advances in biomedical imaging
- Aerospace imaging
- Optical Sensing

Imaging systems and components with special sessions on:

- Image sensors
- Image systems design and simulation
- Image processing

RPPR Final Report

as of 03-Jan-2019

- Multispectral, hyperspectral and thermal imaging
- Computational Imaging
- Novel imaging optics including metamaterials, freeform optics, diffractive optics, polarization, and programmable optics

The meeting highlighted the leading-edge use of imaging systems in consumer imaging, automotive and drone imaging, photography and digital cinematography capture and projection, remote sensing, microscopy, invasive and non-invasive surgery, and airborne and astronomical observations and imaging.

The IS program consisted of plenary and technical sessions, networking events, professional development programs, poster presentations and research sharing. The curriculum structure allowed for student education, networking, and opportunities for students to interact with lecturers to enhance professional development.

The Imaging Congress brought together 624 people across 10 topical meetings allowing for greater collaboration and networking. As part of this larger congress, the IS Topical Meeting convened 44 participants for 60 total presentations including 15 invited talks, 26 contributed oral presentations and 19 contributed poster presentations.

Meeting Outcomes

1. The meetings' attendees presented a diversity of cutting-edge research and discuss technological solutions to imaging challenges and applications.
2. The meeting included invited and contributed presentations and opportunities for special events that include plenary and joint sessions, panels, short courses, exhibits, poster sessions, professional development and networking events.
3. Students and early career professionals presented their work, participate in professional development activities, and heard from and network with internationally-renowned invited speakers who represent the broad diversity of the imaging field.
4. Summaries of accepted papers were published in OSA Publishing's Digital Library and indexed in Ei Compendex and Scopus to provide a direct forum for peer-reviewed publications of the research presented in the meeting.
5. Participants heard about the latest products and services, learn about entrepreneurial opportunities and how scientific innovations translate to the market.

Significant Results

1. The Imaging Congress brought together 624 people across 10 topical meetings allowing for greater collaboration and networking. As part of this larger congress, the Imaging Systems topical meeting convened 44 participants for 60 total presentations including 15 invited talks, 26 contributed oral presentations and 19 contributed poster presentations.
2. 14 students attended the IS meeting.
3. IS hosted 5 participating companies.
4. OSA provided the staffing and support for the planning and execution of the program throughout the whole performance period. Additional funds were sought to help lower the costs to all students and provide travel grants to ensure that deserving students in need of assistance were able to attend.
5. The ARO grant funds were used to cover travel and registration costs for 7 participants who would have been unable to attend without assistance. A portion of the funds was also used for grant management and processing.
6. There were 11 countries represented.
7. IS provided diversity in student enrollment, including 14% female students.

RPPR Final Report

as of 03-Jan-2019

Training Opportunities: 1. Poster Sessions

Posters are an integral part of the technical program and offer a unique networking opportunity, where presenters can discuss their results one-to-one with interested parties. The congress featured three different poster sessions.

2. Student Grand Challenge: The Optical Systems of the Future

The challenge was open to OSA student members and their advisors interested in presenting concepts for enhanced machine visioning or systems that enhance the human vision system by augmenting or extending another human sense. Submissions were evaluated by a committee of Imaging and Applied Optics Congress leadership and Lockheed Martin executives.

3. AIO Technology Demonstrations

The Applied Industrial Optics meeting highlighted emerging technologies, with talks focusing on technical challenges and the path from lab to prototype and beyond. This year emerging technologies were showcased in Technology Demos following selected Invited Talks.

4. Digital Holographic Microscopy: Present and Future Panel Discussion

The OSA Holography and Diffractive Optics Technical Group presented a panel discussion exploring potential breakthroughs in digital holographic microscopy. Brief presentations from the featured panelists were followed by a moderated question and answer session, helping facilitate the exchange of information with the community.

5. OSA Light the Future Speakers Series

To celebrate The Optical Society's 100th anniversary, OSA established the Light The Future speaker series at eight international events in 2016 for conference attendees, invited guests and the local community. The program which features visionaries, futurists and Nobel Prize winners who brings an illuminating topic alive continues in 2018. During the Imaging and Applied Optics Congress, Jason Eichenholz, CTO and Co-Founder of Luminar Technologies, presented a talk as part of the Light the Future series.

6. Student & Early Career Professional Development & Networking Lunch and Learn

This program provided a unique opportunity for students and early career professionals, who are close to finishing or who have recently finished their doctorate degree, to interact with experienced researchers. Key industry and academic leaders in the community were matched for each student based on the student's preference or similarity of research interests. Students had an opportunity to discuss their ongoing research and career plans with their mentor, while mentors shared their professional journey and provide useful tips to those who attend.

7. 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman

This year marks the 50th anniversary of the publishing of Introduction to Fourier Optics by Joseph Goodman, a book that has fundamental influence in the field of optical imaging. To commemorate this anniversary a special series of talks were presented covering Fourier optics in the classroom to the evolvement of the field.

8. Illumicon II

Building on the declarations established at the inaugural Illumicon, which was convened in 2016, attendees came together to discuss and debate emerging trends, technologies and opportunities in advanced 3D displays. The discussions also sought input on how the Display Technology Technical Group can further engage the 3D community in the years ahead.

9. Applications of Visual Science Technical Group Networking Lunch

Members of the OSA Applications of Visual Science Technical Group were invited to attend a networking lunch on Wednesday. The event provided an opportunity to connect with fellow attendees who share an interest in this field and to learn more about this technical group.

10. Tour of Laser Propagation Facilities at Kennedy Space Center

During this tour at Kennedy Space Center (KSC), participants saw various facilities used for outside field experiments such as laser propagation measurements. The tour included UCF's Townes Institute Science and Technology Experimentation Facility (TISTEF), the Shuttle Landing Facility (SLF), and Vehicle Assembly Building (VAB). TISTEF is a site for experiments that require deployment in a fielded setting and consists of a 1 km grass range equipped with atmospheric monitoring instruments and multiple scintillometers as well as capabilities for optical tracking and remote sensing. From this site, slant path measurements can be made over the 13 km path to the top of the VAB. The 5 km long SLF is ideal for longer path measurements because of its homogeneity and flatness (earth's curvature has been removed). This tour was possible because of the pcAOP committee and University of Central Florida.

RPPR Final Report as of 03-Jan-2019

Results Dissemination: The results of the IS Meeting have been disseminated to communities of interest through the following channels:

- OSA website (https://www.osa.org/en-us/meetings/osa_meeting_archives/2018/imaging_systems_and_applications/#Committee)
- OSA Publishing's Digital Library and indexed in Ei Compendex and Scopus (<https://www.osapublishing.org/conference.cfm?meetingid=126&yr=2018>)
- Program Book (https://www.osa.org/osaorg/media/osa.media/Meetings/Archives/2018/2018_Imaging_Program.pdf?ext=.pdf)

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI

Participant: Thomas Giallorenzi

Person Months Worked: 1.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

Participant Type: Other Professional

Participant: Marjorie Morgan

Person Months Worked: 2.00

Funding Support:

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Conference Support for the 2018 Imaging Systems and Applications (IS) Topical Meeting
CONFERENCE PROCEEDINGS**

Submitted to:

U. S. Army Research Office
ATTN: Dr. Dawanne Poree
P. O. Box 12211
Research Triangle Park, NC 27709-2211

Submitted from:

The Optical Society (OSA)
2010 Massachusetts Ave NW
Washington, D.C. 20036
IRS NO. 53-0259696

Grant Information:

Project Title:	Conference Support for the 2018 Imaging Systems and Applications (IS) Topical Meeting
Award Number:	W911NF1810174
Performance Period:	10 May 2018 – 9 November 2018
Award Budget:	\$5,000
Project Investigator:	Dr. Thomas Giallorenzi, grants@osa.org, 202-416-1925
Report Type:	Final

FOREWORD

The Optical Society received a grant in the amount of \$5,000 from the U.S. Army Research Office (ARO) for the support of the 2018 Imaging Systems and Applications (IS) Topical Meeting, which was held in Orlando, Florida United States on 25–28 June 2018. This support is greatly appreciated.

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Appendix B. List of Invited and Contributed Oral Presentations

Appendix C. List of IS Committee Members

Appendix D. Program Book

DISTRIBUTION STATEMENT

DISTRIBUTION A. Approved for public release: distribution unlimited.

ABSTRACT

Imaging Systems and Applications (IS) Meeting was a four-day conference specializing in imaging system design and components, imaging modalities and systems, and applications of military, industrial, medical and consumer imaging. It exposed attendees to in-depth learning of optical sensing and imaging and their applications from internationally recognized academic and industry leaders in the field. Invited speakers from the military, academic, and commercial imaging sectors addressed the current status and future of imaging technologies and capabilities in their organizations.

The IS Meeting was one of the ten topical meetings at the OSA Imaging and Applied Optics Congress (Imaging) that addressed the challenges faced by the imaging community. The goal of the IS meeting was to provide a timely and comprehensive view of the latest developments in imaging and applied optical sciences, covering the forefront advances in imaging and applied optics as well as the application of these technologies to important industrial, military and medical challenges. The topical meeting was designed to address the latest technological advances in digital image signal processing, data extraction and display, and sensor system development. Both commercial as well as military oriented imaging problems were discussed leading to the exchange of information and techniques between these communities. Problems holding up system implementation or representing processing limitations were also discussed as well the latest techniques and approaches to address these problems. This meeting also presented an informal opportunity for attendees to network with recognized experts in the various imaging disciplines and to foster a collaborative environment.

The Imaging Congress brought together 624 people across 10 topical meetings allowing for greater collaboration and networking. As part of this larger congress, the IS Topical Meeting convened 44 participants for 60 total presentations including 15 invited talks, 26 contributed oral presentations and 19 contributed poster presentations.

MAJOR GOALS

1. Create a program that focuses on cutting-edge research and innovative new tools and techniques to increase fundamental knowledge in in the field of imaging and corresponding technologies.
2. Gather distinguished experts in imaging research and applications, foster in-depth exploration of topics, and facilitate one-on-one interactions through the meeting organization.
3. Share groundbreaking research with colleagues, luminaries and industry leaders through peer-reviewed papers that ensure high-quality presentations on important, timely and emerging topics to discuss technology development and its applications.

4. Engage with industry and offer opportunities to meet with exhibitors during the exhibit and industry sessions.
5. Provide opportunities for students and early career professionals to present their work and interact with experts in the field, as well as to participate in professional development events.
6. Provide support for attendees with limited resources to travel and attend the meeting to learn from and interact with leaders in the field.

ACCOMPLISHMENTS

Imaging Systems and Applications (IS) Meeting was a four-day conference that exposed attendees to in-depth learning of optical sensing and imaging. IS brought together experts from many different scientific and engineering disciplines who contribute to the design and integration of optics, sensors, digital processing and displays in imaging systems. IS captures the state-of-the-art in unique light gathering optics, image sensor architectures and technology, on and off chip digital image processing, and methods for compression, storage, transmission, and utilization. The meeting discussed the following topics:

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- Novel imaging optics including metamaterials, freeform optics, diffractive optics, polarization, and programmable optics

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Please see Appendix for a detailed schedule and list of presentations.

Meeting Outcomes

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6. There were 11 countries represented.
7. IS provided diversity in student enrollment, including 14% female students.

ARO Grant Funds

1. Participants Support		\$4,000
David Sampson	University of Surrey	\$690
Geoffrey McKnight	HRL Laboratories, LLC	\$690
Ignacio Zuleta	Planet	\$690
Jane Sprigg	Tarsier Optics	\$690
Natsumi Kawashima	Kagawa University	\$395
Sarah Dean	Berkeley	\$395
Juliet Gopinath	University of Colorado	\$450
2. Project Management Support		\$1,000

Invited Speakers and their Presentations

- Claude Boccara, *Institut Langevin, France*
Ultra-High Resolution Full-Field OCT (FFOCT) for Cornea and Retina
- Dmitry Dylov, *Skolkovo Instit Science and Technology, Russia*
Integrated tissue analytics for clinical imaging systems
- Katsumasa Fujita, *Osaka University, Japan*
Super-resolution confocal microscopy using optical nonlinearity
- Juliet Gopinath, *University of Colorado at Boulder, United States*
Adaptive electrowetting optical devices for imaging
- Boris Gramatikov, *Johns Hopkins University, United States*
Integrating Retinal Birefringence Scanning and Optical Coherence Tomography for Pediatric Retinal Imaging
- Sanjeev Koppal, *University of Florida, United States*
Toward Miniature Computer Vision Sensors
- Geoffrey McKnight, *HRL Laboratories, LLC*
Spherically Curved Image Sensors
- Hirotaka Murakami, *Sony Electronics*
CMOS Image Sensor Evolution toward Sensing World
- Shuo Pang, *University of Central Florida, CREOL, United States*
Spatiotemporally Encoded Fast Fluorescence Microscopy with Full Field-of-View
- Clara Rivero-Baleine, *Lockheed Martin, United States*
Engineered Materials for Next Generation EO/IR Sensors
- Antonio Robles-Kelly, *CSIRO Australia Telescope Natl Facility*
A Multispectral Light Field Camera for 3D Imaging from a Single Lens

- David Sampson, *University of Surrey, United Kingdom*
Angiography, Lymphangiography, Elastography, and Polarisation Contrast Extensions of Optical Coherence Tomography
- Jane Sprigg, *Tarsier Optics, United States*
Incoherent Super-resolution Imaging
- Nelson Tabiryan, *Beam Engineering for Adv Measurements Co, United States*
Electrically Switchable Large, Thin, and Fast Optics
- C Alex Young, *NASA, United States*
Eclipse Ballooning Project

Plenary Sessions

- Paul Debevec, *Google VR, USA*
Light Fields and Light Stages for Photoreal Movies, Games, and Virtual Reality
- Jason Eichenholz, *Luminar Technologies, USA*
The Role of Optics and Photonics in the Vehicles of Tomorrow
- Laurent Pueyo, *Space Telescope Science Institute, USA*
Exoplanet Imaging: From Precision Optics to Precision Measurements

Training and Professional Development Opportunities

1. Poster Sessions

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- Program Book (https://www.osa.org/osaorg/media/osa.media/Meetings/Archives/2018/2018_Imaging_Program.pdf?ext=.pdf)

APPENDIX

Appendix A. Schedule

Agenda of Sessions — Sunday, 24 June

15:00–18:00	Registration, Palms Foyer
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Monday, 25 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/Lime	Citron	Clementine	Mandarin
	AIO	IS	LACSEA	MATH	COSI	DH	3D	LS&C
07:00–18:30	Registration, Palms Foyer							
08:00–09:30	JM1A • Plenary Session I, Citron							
09:30–10:30	Coffee Break with Exhibitors, Palms Foyer							
10:30–12:30	AM2A • You Say LIDAR, I Say LADAR	IM2B • Thin Optics and Optical Design	LM2C • Ultra-fast techniques & high-speed imaging	MM2D • Tomography	CM2E • Indirect and non-line-of-sight imaging	DM2F • Advances in DH Techniques I	3M2G • Holographic Display	SM2H • Free Space Communications (ends at 12:00)
12:30–14:00	Lunch on your Own							
12:30–14:00	Digital Holographic Microscopy: Present and Future Panel Discussion, Salon C							
14:00–16:00	AM3A • Spectroscopy, Microscopy, and Fiberscopy	IM3B • Biomedical Imaging I	LM3C • Novel techniques & special applications	MM3D • Imaging in complex media	JM3E • Not Your Dentist's X-ray (COSI/AIO)	DM3F • Incoherent Holography	3M3G • Measurement I	SM3H • Sensing I
16:00–17:00	JM4A • Poster Session I and Coffee Break with Exhibitors, Palms Foyer and Ballroom FGHl							
17:00–18:30	AM5A • Look To The Stars	IM5B • Biomedical Imaging II	LM5C • Atmospheric & environmental monitoring I	MM5D • Inverse scattering	CM5E • Depth-resolved and turbid imaging	DM5F • Applications of DH	3M5G • HMD & Aerial Display	SM5H • Sensing II
18:30–20:00	Congress Reception, Palms Ballroom E							

Agenda of Sessions — Tuesday, 26 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/Lime	Citron	Clementine	Mandarin	Tangerine
	AIO	IS	LACSEA	MATH/COSI	COSI	DH	3D	LS&C	pcAOP
07:00–18:30	Registration, Palms Foyer								
08:00–09:00	JT1A • Plenary Session II with the Light the Future Speaker Series, Citron								
09:00–10:00	Coffee Break with Exhibitors, Palms Foyer								
10:00–12:00	ATu2A • Keynote and Laser Sorcery	ITu2B • Microscopy I: Super-resolution & Illumination Techniques	LTu2C • Combustion Diagnostics I	MTu2D • High-dimensional imaging	CTu2E • Compressive sensing I	DTu2F • Contemporary Topics in DH	3Tu2G • HMD & VAC Solution	STu2H • Components I	PTu2I • Propagation Simulations
12:00–13:30	Light the Future Lunch, Palm Foyer								
12:30–14:00	Student & Early Career Professional Development & Networking Lunch and Learn, Jasmine								
13:30–15:30	ATu3A • Fiber Sensory Overload	ITu3B • Microscopy II: 3D & High Speed Techniques (starts at 14:00)	LTu3C • Combustion diagnostics II		JTu3D • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman		3Tu3E • Compressing & Integral imaging sensing (Light Field)	STu3F • Quantum Protocols I (starts at 14:30)	PTu3G • Underwater Propagation (starts at 14:15)
15:30–16:30	JT4A • Poster Session II and Coffee Break with Exhibitors, Palms Foyer and Ballroom FGHl								
16:30–18:30	ATu5A • Bridging Two Worlds: Academics and Industry	JTu5B • Microscopy & Imaging (IS/AO)	LTu5C • Atmospheric & environmental monitoring II	CTu5D • Compressive sensing 2: spectral imaging	JTu5E • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman	DTu5F • Computer-Generated Holograms	3Tu5G • 360-degree display and perception	STu5H • Quantum Protocols II	PTu5I • Propagation In Scattering Media
18:30–19:30	50th Anniversary of Introduction to Fourier Optics by Joseph Goodman Reception, Orange/Lemon/Lime								
19:00–21:00	Illumicon II, A secret location								

Agenda of Sessions — Wednesday, 27 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon	Citron	Clementine	Mandarin	Tangerine	Lime
	AIO	IS/COSI	LACSEA	MATH	COSI	DH	3D	LS&C	pcAOP	AO
07:30–18:30	Registration, <i>Palms Foyer</i>									
08:00–09:00	JW1A • Plenary Session III, <i>Citron</i>									
09:00–10:00	Coffee Break with Exhibitors, <i>Palms Foyer</i>									
10:00–12:00	AW2A • You Down With OCT (Yeah You Know Me)	IW2B • Computer Vision & Image Processing	LW2C • Velocimetry, films & fundamentals	MW2D • Sparsity based priors	CW2E • Computational microscopy	DW2F • Deep Learning in DH	3W2G • Measurement II	SW2H • Quantum Protocols III	PW2I • Atmospheric Propagation	OW2J • Wavefront/ Beam Control & Sensing I
12:00–13:00	Applications of Visual Science Technical Group Networking Lunch, <i>Salon C</i>									
12:00–13:30	Lunch on your Own									
13:30–15:30	AW3A • Animal Optics: The Facts of Light	CW3B • Machine Learning in Computational Sensing and Imaging I	LW3C • Techniques for reactors, shock tubes & cells	MW3D • Application in 3D Microscopy	JW3E • Aerospace Imaging (COSI/IS)	DW3F • Multi-wavelength Digital Holography	3W3G • Light Field Display	SW3H • Components II (ends at 14:30)	PW3I • Environmental Propagation	OW3J • Wavefront/ Beam Control & Sensing II (ends at 15:00)
15:30–16:30	JW4A • Poster Session III Coffee Break with Exhibitors, <i>Palms Foyer and Ballroom FGH</i>									
16:30–18:30	AW5A • Orlando: The New Silicon Valley?	CW5B • Machine Learning in Computational Sensing and Imaging II	LW5C • Ultra-fast techniques & high-speed imaging II	MW5D • Model-based imaging	JW5E • Spectral Imaging (COSI/IS)	DW5F • OptoFluidic and Life Applications of DH	3W5G • Interferometry & OCT			JW5I • Turbulence & Propagation (pcAOP/AO)

Agenda of Sessions — Thursday, 28 June

	Sunset/Fleming	Siesta/Biscayne	Cedar/Marathon	Orange/Lemon/Lime	Citron	Clementine
	AIO	Joint	DH	COSI	DH	AO
07:30–16:00	Registration, <i>Palms Foyer</i>					
08:00–09:00	Postdeadline Papers (schedule and location listed in the congress update sheet)					
09:00–09:45	Coffee Break with Exhibitors, <i>Palms Foyer</i>					
09:45–11:45	ATh2A • Another Day, Another Detector	ITh2B • Sensors & Optics	DTk2C • Digital Holographic Microscopy	CTh2D • Phase retrieval	DTk2E • Advances in DH Techniques 2	OTk2F • AO Systems II
11:45–13:30	Lunch on your Own					
13:00–18:00	Tour of Laser Propagation Facilities at Kennedy Space Center (Extra fee and advanced registration required.)					
13:30–15:30	JTh3A • Ptychography, It's Complex (AIO/COSI)	JTh3B • Holographic Microscopy (COSI/DH)		CTh3C • Imaging through aberrations, Structured illumination & super resolution	DTk3D • Integral Imaging and Holographic Displays	OTk3E • Control & Simulations
15:30–16:00	Coffee Break with Exhibitors, <i>Palms Foyer</i>					
16:00–18:00				CTh4A • Quantum computational imaging	DTk4B • System Design and Data Processing in DH	OTk4C • Adaptive Optics Systems for the Eye

Appendix B. List of Invited and Contributed Oral Presentations

N. Tabiryan, J. Hwang, H. Xianyu, S. Serak, S. Nersisyan, B. Kimball, D. Steeves, M. McConney, and T. Bunning, "Electrically switchable large, thin, and fast optics," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM2B.1.

C. YOUSEFZADEH, A. JAMALI, C. MCGINTY, and P. BOS, "Achromatic Test of Pancharatnam Phase Lens for VR/AR," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM2B.2.

A. Lyons, C. Altuzarra, G. Yuan, C. Simpson, T. Roger, and D. Faccio, "Non-local Control of a Metasurface Image," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM2B.3.

M. Dupr  , J. Park, L. Hsu, A. Ndao, and B. Kant  , "Towards Random Metasurface based Devices," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM2B.4.

A. Diebold, M. Imani, T. Sleasman, and D. Smith, "Reflective microwave ghost imaging with dynamic metasurface apertures," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM2B.5.

A. Rakhman, W. Blokland, S. Rajic, and M. Rennich, "The Proton Beam Imaging System Design for the Spallation Neutron Source Tungsten Target," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM2B.6.

C. Olson, "Encoding Optical Architectures via Gene Expression Programming," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM2B.7.

V. Mazlin, P. Xiao, J. Scholler, K. Grieve, K. Irsch, J. Sahel, M. Fink, and C. Boccara, "Ultra-High Resolution Full-Field OCT (FFOCT) for Cornea and Retina," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM3B.1.

M. Roy, W. Zheng, and C. Sheppard, "Rapid Full-Field Optical Coherence Tomography Using Geometric Phase Ferroelectric Liquid Crystal Technology," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM3B.2.

C. Llorens-Quintana, P. Syga, and D. Iskander, "Automated Image Processing Algorithm for

Infrared Meibography," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM3B.3.

B. Gramatikov, K. Irsch, and D. Guyton, "Integrating Retinal Birefringence Scanning and Optical Coherence Tomography for Pediatric Retinal Imaging," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IM3B.4.

Z. Ma and C. Renshaw, "2-Terminal Organic FPA Pixel Design for Curved Image Sensors," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITh2B.3.

M. Larsen, "Infrared Monolithic Double Diffractive Kinoform Doublet on a Planar Substrate - Coupled Design Model," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITh2B.5.

K. Fujita, "Super-resolution confocal microscopy using optical nonlinearity," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu2B.1.

G. Lim, W. Kim, H. Yi, and N. Park, "Improved Lateral Resolution of Continuous Wave STED Microscopy using Standing Wave in focus," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu2B.2.

S. Bedoya, A. Doblas, G. Saavedra, and C. Preza, "Tunable structured illumination system based on a Wollaston prism," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu2B.3.

S. Dean, Z. Phillips, L. Waller, and B. Recht, "Optimal Path and Illumination Design for Multiframe Motion Deblurring," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu2B.4.

A. Steinforth, J. Rivera, and J. Eden, "Speckle-Free Imaging with Nanosecond-Scale Acquisition Using Microlens-Stabilized Laser Arrays," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu2B.5.

C. Cecala, E. Bittner, and E. Null, "Imaging and quantitating abrasion damage on transparent substrates using edge light illumination," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu2B.6.

S. Pang, "Compressive high-speed imaging in fluorescence microscopy and 3D photography," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu3B.1.

T. Yamashita, H. Chiba, K. Yamato, and H. Oku, "Development of a coded exposure camera for high-speed 3D measurement using microscope," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu3B.2.

Y. Lu, K. Zhu, S. Zhang, and Y. Tan, "Depth of Focus Extension based on a Laser Frequency-shifted Feedback Imaging System," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu3B.3.

C. Pichette, M. PichÃ©, P. Marquet, and S. Thibault, "Temporal Study of Photonic Jet Formations under Ultrashort Laser Pulses Illumination for Different Geometries in Near-field Optical Microscopy," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper ITu3B.4.

A. Travinsky and Z. Ninkov, "Measurement of Modulation Transfer Function using Digital Micromirror Devices," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IW2B.2.

J. BriÃ±ez de LeÃ³n, H. FandiÃ±o Toro, A. Restrepo M, and J. Branch, "Bayer and demosaicking effect for imaging the stress field in digital photoelasticity," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IW2B.3.

K. Dorozynska and E. Kristensson, "Illumination Pattern Estimation for Multiple Exposures Extraction in a Snapshot Imaging Technique," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IW2B.5.

M. Tancik, T. Swedish, G. Satat, and R. Raskar, "Data-Driven Non-Line-of-Sight Imaging With A Traditional Camera," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper IW2B.6.

W. Eschen, G. Tadesse, R. Klas, M. Tschernajew, F. Tuitje, C. Spielmann, A. TÃ¼nnemann, J. Limpert, and J. Rothhardt, "High Resolution Ptychographic Coherent Diffractive Imaging using Table-top XUV Sources," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JM3E.4.

A. Kadambi, A. Cramer, R. Lanza, R. Raskar, and R. Gupta, "Computational X-ray Imaging using Document Scanners," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JM3E.5.

B. Chen, P. Sidorenko, O. Lahav, O. Peleg, and O. Cohen, "Multiplexed Single-Shot Ptychography," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3A.2.

T. Aidukas, A. Harvey, and P. Konda, "Fourier Ptychography Using Low-Cost Bayer Color Sensors," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3A.3.

G. Haham, O. Peleg, P. Sidorenko, and O. Cohen, "High-resolution (diffraction limit) single-shot ptychography for ultrahigh-speed microscopy," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3A.4.

A. Zhou, W. Wang, N. Chen, and G. Situ, "Fast light source misalignment correction of Fourier ptychographic microscopy," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3A.5.

T. Nguyen, Y. Xue, W. Tahir, Y. Li, L. Tian, and G. Nehmetallah, "A deep-learning approach for high-speed Fourier ptychographic microscopy," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3A.6.

W. Tahir, U. Kamilov, and L. Tian, "Sampling and processing for multiple scattering in inline compressive holography," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3B.1.

X. Hua, C. Yang, B. Xu, F. Yan, and X. Cao, "Multi-constrained Phase Retrieval for Lens-Free Inline holographic microscopy," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3B.2.

S. Li, S. Feng, J. Ma, Q. Ma, and C. Yuan, "Resolution Enhancement in Digital Holographic Microscopy under Grating-based Illumination," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3B.3.

V. Lam, G. Nehmetallah, B. Chung, and C. Raub, "The effects of cytokeratin knock-out on

breast cancer cell phase features assessed with telecentric digital holographic microscopy (DHM) and machine learning," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3B.4.

Z. Ren, Z. Xu, and E. Lam, "Phase aberration compensation in digital holographic microscopy using regression analysis," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3B.5.

D. Deng, W. Qu, W. He, X. Liu, and X. Peng, "Total aberrations compensation for digital holographic microscopy with geometrical transformations," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTh3B.6.

K. Tehrani, P. Kner, and L. Mortensen, "Intravital multi-photon imaging through intact highly scattering bone using binary wavefront optimization," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTU5B.2.

J. Girkin, C. Buckley, M. Torres-Carvalho, L. Young, S. Rider, and J. Mullins, "Adaptive Optics for Precise Cell Ablation in vivo," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTU5B.3.

D. Wilding and R. Fiolka, "Two-Photon light-sheet microscope with adaptive optics in the illumination and detection path," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTU5B.5.

P. Smid, C. See, and A. Wright, "Modal aberration correction in confocal microscope with CCD camera detection," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTU5B.6.

V. Barolle, A. Badon, L. Cobus, K. Irsch, C. Boccara, M. Fink, and A. Aubry, "Matrix approach of optical coherence tomography for in-depth imaging of biological tissues," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTU5B.7.

J. Fienup, "ABCD Matrix Analysis for Fourier-Optics Imaging," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JTU5E.2.

M. Mansuripur, "Fourier Optics in the Classroom," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical

Society of America, 2018), paper JTU5E.3.

J. Wu, E. Li, X. Shen, Z. Tong, C. Hu, Z. Liu, S. Liu, and S. Han, "Snapshot Spectral Imaging Experiment on Tethered Balloon," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW3E.4.

A. Robles-Kelly, R. Wei, and S. You, "A Multispectral Light Field Camera for 3D Imaging from a Single Lens," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5E.1.

H. Guerboukha, K. Nallappan, and M. Skorobogatiy, "Toward Real-time Terahertz Imaging with Spectral Encoding of the k-space," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5E.2.

S. Liu, Z. Liu, J. Wu, Z. Tong, C. Hu, and S. Han, "Hyperspectral ghost imaging camera based on a flat-field grating," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5E.3.

S. Bahk and C. Dorrer, "Multispectral Wavefront Sensing for Characterizing Spatiotemporal Coupling in Ultrashort Pulses," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5E.4.

K. Sanchez, C. Hinojosa, and H. Arguello, "Supervised Classification of Hyperspectral Images using Side Information," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5E.5.

M. Baranski, S. Muttikulangara, G. Barbastathis, and J. Miao, "Highly crosstalked integral field spectrometer with computational inversion," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5E.6.

C. Hinojosa, J. Bacca, and H. Arguello, "Spectral Imaging Subspace Clustering with 3-D Spatial Regularizer," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5E.7.

E. Masciadri, A. Turchi, and L. Fini, "Optical turbulence forecast in the Adaptive Optics realm," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5I.1.

C. Fernandez and G. Bennett, "Comparison of Measurement Techniques Used to Determine Atmospheric Structure Parameter," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5I.2.

I. Toselli and S. Gladysz, "Adaptive Optics Correction for Oceanic Turbulence-Affected Laser Beams," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5I.3.

S. Gladysz and E. Anzuola, "Generating Infinitely Long Phase-Screens with the Karhunen-Lo ve Decomposition," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5I.4.

J. Osborn, "Characterising atmospheric turbulence using SCIDAR techniques," in *Imaging and Applied Optics 2018 (3D, AO, AIO, COSI, DH, IS, LACSEA, LS&C, MATH, pcAOP)*, OSA Technical Digest (Optical Society of America, 2018), paper JW5I.5.

Appendix C. List of IS Committee Members

Matthew Arnison, Canon Info. Sys. Research Australia, Australia , Chair
Michael Groenert, US Army RDECOM CERDEC, United States , Chair
Ginni Grover, Intel Corporation, United States , Program Chair
Kristina Irsch, Johns Hopkins University & Sorbonne Univ, United States , Program Chair
Kenneth Barnard, US Air Force Research Laboratory, United States
Peter Catrysse, Stanford University, United States
Christopher Dainty, FotoNation, Ireland
Mini Das, University of Houston, United States
Aristide Dogariu, University of Central Florida, CREOL, United States
Joyce Farrell, Stanford University, United States
Boyd Fowler, Omnivision Technologies, United States
Kevin Gemp, MITRE Corp, United States
Francisco Imai, Apple Inc., United States
Chulmin Joo, Yonsei University, South Korea
Byoung-ho Lee, Seoul National University, South Korea
Ofer Levi, University of Toronto, Canada
Dale Linne von Berg, US Naval Research Laboratory, United States
Rajesh Menon, University of Utah, United States
Lise Randeberg, Norges Teknisk Naturvitenskapelige Univ, Norway
Maitreyee Roy, University of New South Wales, Australia
Todd Sachs, Apple Inc., United States
Casey Streuber, Raytheon Missile Systems, United States
Jay Vizgaitis, optX imaging systems, United States
Laura Waller, University of California Berkeley, United States
Zeev Zalevsky, Bar-Ilan University, Israel

OSA Imaging and Applied Optics Congress

25–28 June 2018

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Topics from the Imaging and Applied Optics Congress

COMPUTATIONAL OPTICAL SENSING & IMAGING (COSI)

This *Applied Optics* Feature Issue will highlight the latest advances in computational imaging research, including everything from fundamental science to medical, security, and defense industry applications.

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Abbie Watnik (Lead Editor), *US Naval Research Laboratory, USA*

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DIGITAL HOLOGRAPHY & 3-D IMAGING

Applied Optics and the *Journal of the Optical Society of America A* will publish a Joint Feature Issue covering topics such as computer-generated holograms, holographic lithography, biomedical imaging, and holographic remote sensing.

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For more information and submission deadlines, visit osapublishing.org/ao/feature.cfm

Conference Materials

Access to the Wireless Internet

OSA has provided complimentary Wifi for all conference attendees. Wifi can be accessed in the meeting room space.

Network: Wyndham Conference HSIA

Password: 2018jun

Online Access to Technical Digest

Full Technical Attendees have both EARLY and FREE continuous online access to the Congress Technical Digest including the Postdeadline papers through OSA Publishing's Digital Library. The presented papers can be downloaded individually or by downloading .zip files (.zip files are available for 60 days).

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Authors presenting posters have the option to submit the PDF of their poster, which will be attached to their papers in OSA Publishing's Digital Library. If submitted, poster PDFs will be available about two weeks after the meeting. While accessing the papers in OSA Publishing's Digital Library look for the multimedia symbol shown above.

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Student Grand Challenge: The Optical Systems of the Future

The challenge was open to OSA student members and their advisors interested in presenting concepts for enhanced machine visioning or systems that enhance the human vision system by augmenting or extending another human sense.

Passive Optical System Challenge Problem

The image processing community strives to duplicate human vision. For certain specific and well defined tasks we have succeeded or surpassed human capability, but still struggle with poorly defined and dynamic environments. The category comparison between machine vision and human vision include:

- Spectrum: Machine vision is superior as human vision is limited to the visible spectrum. Machine vision is also more capable of seeing narrower spectrum steps and larger dynamic ranges than our eyes.
- Resolution: Human vision is superior. Current machine vision systems that are approaching 8K x 8K formats are starting to get there but, only with visible systems.
- Focus: Human vision is superior being able to focus from very close to very far with a single lens element. The eye aperture is limited by the size of the pupil for objects far away. Machine vision systems are specifically designed for very close or very far away and do not suffer from being aperture limited, but utilize many lens elements to accomplish the same human eye tasks.
- Optical Processing: Human vision + brain is superior to machine vision on pattern recognition and decision making.

The passive optical systems challenge was to create a novel concept, technology or system for improving results in one of the 8 categories below:

- Image Processing: Ideas focused on detection and categorization of objects in the view field.
- Lens Technology: Ideas that are focused on optical sensors.
- High Speed Data Transport: Ideas that are focused on fast and efficient transport of high resolution image data and streams.
- Adaptable Lens Technology: Ideas that are focused on adaptable optical sensors.
- Liquid Lens Optical Sensors: Ideas focused on liquid lens.
- Artificial Intelligence: Ideas that focus on image based cognition
- AV/VR Technology: Ideas that are focused on Augmented and Virtual Reality technologies.
- Other: Ideas that do not fall into one of the existing categories.

Active Optical System Challenge

Given you have a human vision system, which is intrinsically passive, how would you use active sensing techniques to augment that vision system to mimic or extend the human senses? Augmentation could mean adding higher precision 3D vision, active foveae imaging, active IR assisted sensing, vibrometry, polarimetry, sensing motion in the FOV, chemical/biological sensing, looking through fog/turbulence, etc. Many such systems have been demonstrated, but they are often large, heavy, and costly.

The active optical system challenge is to come up with novel sensor concepts that mimic at least two of the human senses at a distance of at least 10 m, with the sensor fitting into one third of the human brain (roughly 0.5 liters). More sensing modalities are encouraged, especially those that extend what humans can do.

1. Sight (e.g., producing 2D or 3D images)
2. Hearing (e.g., measuring object vibrations through optical means)
3. Smell (e.g., chemical/biological sensing)
4. Taste (e.g., chemical/biological sensing)
5. Touch (e.g., characterization of surface texture and/or temperature)

Finalists

All-passive, Transformable Optical Mapping (ATOM) Wearable Display, **Wei Cui**, *University of Illinois Urbana-Champaign, USA*

ARCADE: Accurate and Rapid Camera for Depth Estimation, **Shay Elmalem**, *Tel-Aviv University, Israel*

Low-Cost/High-Yield Fabrication of Microlens Array for Light-Field Imaging, **Hyun Myung Kim**, *Gwangju Institute of Science and Technology, South Korea*

Extraction of Phase Information from Intensity-only Images using Deep Learning, **Shuai Li**, *Massachusetts Institute of Technology, USA*

Challenge Judging and Winner Announcement

During the conference, attendees will have a chance to review the finalists' concepts by visiting their poster during the Monday and Tuesday poster sessions. Also, during the Tuesday plenary session hear a rapid fire explanation. Each attendee will be asked to vote for the best concept via the Imaging Congress Mobile App.

Winners will be announced during the Wednesday Plenary session and will receive a recognition plaque and a \$250 prize.

Sponsored by



Special Events

Poster Sessions

Monday, 25 June – Wednesday 27 June
Palms Ballroom FGHI

The congress will feature three different poster sessions. The poster presenters should display their poster during the morning break and stand by their poster during the afternoon break to answer questions. Attendee may view the posters all day starting with the morning break and concluding with the afternoon break/poster session. This allows attendees a chance to preview posters at their leisure during the day.

All posters must be removed by 17:00 on the day they are displayed. Posters not removed may be disposed.

AIO Technology Demonstrations

The Applied Industrial Optics meeting highlights emerging technologies, with talks focusing on technical challenges and the path from lab to prototype and beyond. This year emerging technologies will be showcased in Technology Demos following selected Invited Talks. Look for the **DEMO** icon in the abstract section to learn about the demos for the selected invited talks. Each demonstration will take place during the last 15 minutes of the invited talk.

Digital Holographic Microscopy: Present and Future Panel Discussion

Monday, 25 June, 12:30–14:00
Salon C

Join the OSA Holography and Diffractive Optics Technical Group for a panel discussion exploring potential breakthroughs in digital holographic microscopy. Brief presentations from our featured panelists will be followed by a moderated question and answer session, helping facilitate the exchange of information with our community. Contact TGactivities@osa.org to register, pending availability.

Hosted by:  Holography and
Diffractive Optics
Technical Group

Congress Reception

Monday, 25 June; 18:30–20:00
Palms Ballroom E

Come join your colleagues for drinks, networking and thoughtful discussion. Enjoy light fare while networking. The reception is open to all full conference attendees. Conference attendees may purchase extra tickets for their guest.

OSA Light the Future Speakers Series

Tuesday, 26 June; 08:00–09:00
Citron

Imagine self-driving cars, 3D printing and a billion pixel camera. One hundred years ago these inventions were unthinkable. Yet today, researchers and industry leaders around the globe are perfecting such innovations that once were the realm of science fiction. To celebrate The Optical Society's 100th anniversary, OSA established the Light The Future speaker series at eight international events in 2016 for conference attendees, invited guests and the local community. The program which features visionaries, futurists and Nobel Prize winners who will bring an illuminating topic alive will continue in 2018.

During the Imaging and Applied Optics Congress, Jason Eichenholz, CTO and Co-Founder of Luminar Technologies, will present a talk as part of the Light the Future series.

Join us for at 12:30 on Tuesday in the Palms Foyer as the OSA Light the Future program sponsors lunch in celebration of the illuminating topics discussed during the conference.

For more information on the Light the Future program visit www.osa.org/get_involved/light_the_future/

Student & Early Career Professional Development & Networking Lunch and Learn

Tuesday, 26 June; 12:30–14:00
Jasmine

This program will provide a unique opportunity for students and early career professionals, who are close to finishing or who have recently finished their doctorate degree, to interact with experienced researchers. Key industry and academic leaders in the community will be matched for each student based on the student's preference or similarity of research interests. Students will have an opportunity to discuss their ongoing research and career plans with their mentor, while mentors will share their professional journey and provide useful tips to those who attend.

This Workshop is complimentary for OSA Members and there was an application process to be chosen to attend. Not all who apply will be able to attend due to space limitations and priority will be given to those who have most recently or are close to graduation.

50th Anniversary of Introduction to Fourier Optics by Joseph Goodman

Tuesday, 26 June; 13:30–19:30
Orange/Lemon/Lime

This year marks the 50th anniversary of the publishing of *Introduction to Fourier Optics* by Joseph Goodman, a book that has fundamental influence in the field of optical imaging. To commemorate this anniversary a special series of talks will be presented covering Fourier optics in the classroom to the evolvement of the field.

Join the Image Sensing and Pattern Recognition Technical Group for a small reception immediately following the conclusion of the program.

Reception Hosted By



Illumicon II

Tuesday, 26 June 2018, 19:00–21:00

A secret location

You are invited to join the OSA Display Technology Technical Group for Illumicon II, an exclusive members-only event. Building on the declarations established at the inaugural Illumicon, which was convened in 2016, attendees will come together to discuss and debate emerging trends, technologies and opportunities in advanced 3D displays. Our discussions will also seek input on how the Display Technology Technical Group can further engage the 3D community in the years ahead. Illumicon II attendees will converge over drinks and appetizers at the confidential location. Entrance will be granted to those able to provide the secret Illumicon II event password. RSVP to tgactivities@osa.org to receive the event location and password.

Hosted by: 

Applications of Visual Science Technical Group Networking Lunch

Wednesday, 27 June 2018, 12:00–13:00

Salon C

Members of the OSA Applications of Visual Science Technical Group are invited to join us for a networking lunch on Wednesday. The event will provide an opportunity to connect with fellow attendees who share an interest in this field and to learn more about this technical group. Contact TGactivities@osa.org to register, pending availability.

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Tour of Laser Propagation Facilities at Kennedy Space Center

Thursday, 28 June (13:00–18:00) and

Friday, 29 June (07:00–12:00)

During this tour at Kennedy Space Center (KSC), you will see various facilities used for outside field experiments such as laser propagation measurements. The tour will include UCF's Townes Institute Science and Technology Experimentation Facility (TISTEF), the Shuttle Landing Facility (SLF), and Vehicle Assembly Building (VAB). TISTEF is a site for experiments that require deployment in a fielded setting and consists of a 1 km grass range equipped with atmospheric monitoring instruments and multiple scintillometers as well as capabilities for optical tracking and remote sensing. From this site, slant path measurements can be made over the 13 km path to the top of the VAB. The 5 km long SLF is ideal for longer path measurements because of its homogeneity and flatness (earth's curvature has been removed). This tour is possible because of the pcAOP committee and University of Central Florida.

To participate in this tour advanced registration is required and there is an additional fee of \$25 per person.



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Plenary Speakers



Paul Debevec, *Google VR, USA*

Light Fields and Light Stages for Photoreal Movies, Games, and Virtual Reality

Monday, 25 June, 08:00–09:30

Paul Debevec is a research professor at the University of Southern California and the associate director of graphics research at USC's Institute for Creative Technologies. Debevec's Ph.D. thesis (UC Berkeley, 1996) presented *Façade*, an image-based modeling and rendering system for creating photoreal architectural models from photographs. Using *Façade* he led the creation of virtual cinematography of the Berkeley campus for his 1997 film *The Campanile Movie* whose techniques were used to create virtual backgrounds in *The Matrix*. Subsequently, Debevec pioneered high dynamic range image-based lighting techniques in his films *Rendering with Natural Light* (1998), *Fiat Lux* (1999), and *The Parthenon* (2004); he also leads the design of HDR Shop, the first high dynamic range image editing program. At USC ICT, Debevec has led the development of a series of Light Stage devices for capturing and simulating how objects and people reflect light, used to create photoreal digital actors in films such as *Spider Man 2*, *Superman Returns*, and *The Curious Case of Benjamin Button*, and *Avatar*, as well as 3D Display devices for telepresence and teleconferencing. He received ACM SIGGRAPH's first Significant New Researcher Award in 2001, co-authored the 2005 book *High Dynamic Range Imaging* from Morgan Kaufmann, and chaired the SIGGRAPH 2007 Computer Animation Festival. He serves as Vice President of ACM SIGGRAPH and is a member of the Visual Effects Society, the Academy of Motion Picture Arts and Sciences, and the Academy's Science and Technology Council.



Jason Eichenholz, *Luminar Technologies, USA*

The Role of Optics and Photonics in the Vehicles of Tomorrow

Tuesday, 26 June, 08:00–09:00

Jason Eichenholz is a serial entrepreneur and pioneer in laser, optics and photonics product development and commercialization.

Over the course of his twenty-five year career, his unique blend of business and technical leadership has resulted in hundreds of millions of dollars of new photonics products being brought to market. Eichenholz is an inventor on ten U.S. patents on new types of solid-state lasers, displays and photonic devices.



Laurent Pueyo, *Space Telescope Science Institute, USA*

Exoplanet Imaging: From Precision Optics to Precision Measurements

Wednesday, 27 June, 08:00–09:00

Laurent Pueyo is an astronomer at the Space Telescope Science Institute, in Baltimore, Maryland. He

earned his doctorate from Princeton University in 2008 and conducted his post-doctoral work as a NASA Fellow at the Jet Propulsion Laboratory and as a Sagan Fellow at the Johns Hopkins University. His research focuses on imaging faint planets around nearby stars. He has pioneered advanced data analysis methods that are now standard tools used to study extrasolar planets, and invented an optical technique that is now baselined for future NASA missions. At STScI his duties include optimizing the extrasolar-planet imaging capabilities of NASA's James Webb Space Telescope (JWST), scheduled to launch in late 2019. He is also a member of the Science and Technology Definition Team for the Large Ultraviolet Optical and Infrared telescope, a future observatory that will identify Earth-sized planets and assess their habitability.



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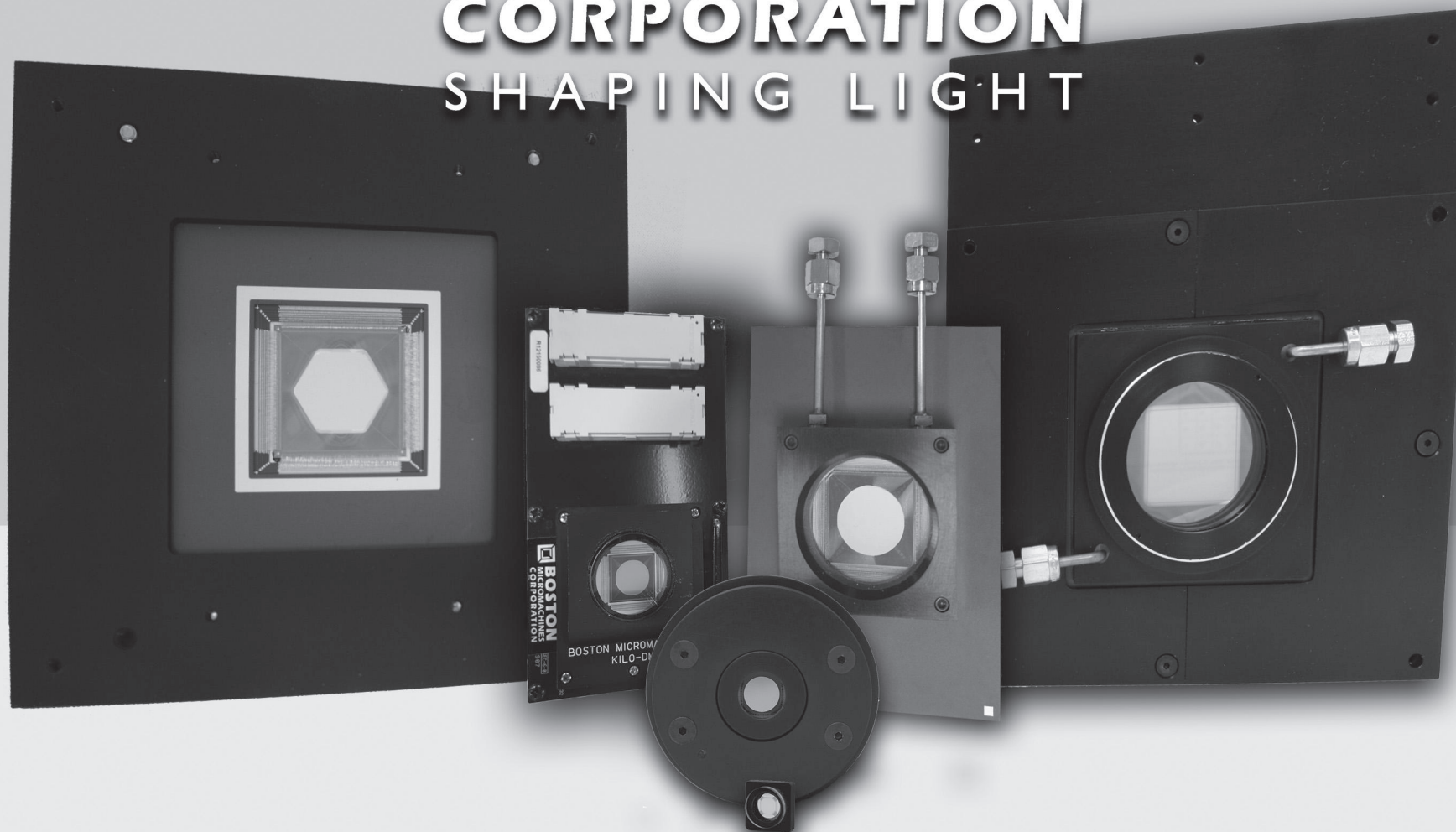
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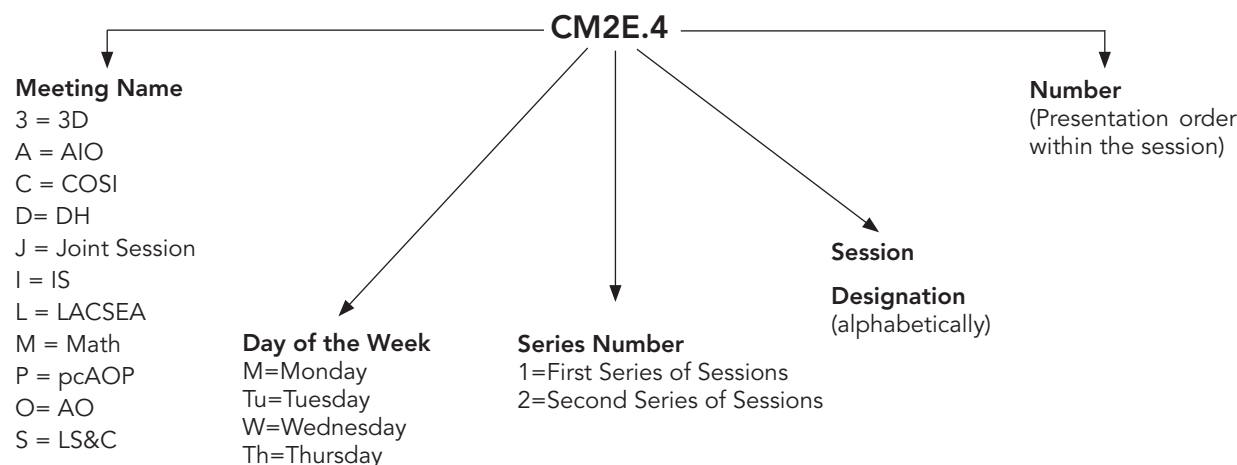
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Boston Micromachines Corporation is the leading provider of microelectromechanical systems (MEMS) mirror products, and has expertise in the design of adaptive optics systems. Our devices are used for wavefront correction and intensity modulation in a variety of applications including laser beam shaping, microscopy, astronomy, and free-space communication.

Explanation of Session Codes



The first letter of the code designates the meeting (3 = 3D, A=AIO, C=COSI, D=DH, J=Joint, I=IS, L=LACSEA, M=MATH, P=pcAOP, O=AO, S= S&C). The second element denotes the day of the week (Monday=M, Tuesday=T, Wednesday=W, Thursday=Th). The third element indicates the session series in that day (for instance, 1 would denote the first parallel sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through a series of parallel sessions. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded CM2E.4 indicates that this paper is part of COSI (C) and is being presented on Monday (M) in the first series of sessions (2), and is the fifth parallel session (E) in that series and the fourth paper (4) presented in that session.

Plenaries are noted with **Plenary**

Keynote talks are noted with **Keynote**

Tutorials are noted with **Tutorial**

Invited talks are noted with **Invited**

AIO Technology Demonstration **DEMO**

Key to Conference Abbreviations

3D	3D Image Acquisition and Display: Technology, Perception and Applications
AIO	Applied Industrial Optics
AO	Adaptive Optics: Methods, Analysis and Applications
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pcAOP	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

Agenda of Sessions — Sunday, 24 June

15:00–18:00	Registration, <i>Palms Foyer</i>
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Monday, 25 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/ Lime	Citron	Clementine	Mandarin
	AIO	IS	LACSEA	MATH	COSI	DH	3D	LS&C
07:00–18:30	Registration, <i>Palms Foyer</i>							
08:00–09:30	JM1A • Plenary Session I, <i>Citron</i>							
09:30–10:30	Coffee Break with Exhibitors, <i>Palms Foyer</i>							
10:30–12:30	AM2A • You Say LIDAR, I Say LADAR	IM2B • Thin Optics and Optical Design	LM2C • Ultra-fast techniques & high-speed imaging	MM2D • Tomography	CM2E • Indirect and non-line-of-sight imaging	DM2F • Advances in DH Techniques I	3M2G • Holographic Display	SM2H • Free Space Communications (ends at 12:00)
12:30–14:00	Lunch on your Own							
12:30–14:00	Digital Holographic Microscopy: Present and Future Panel Discussion, <i>Salon C</i>							
14:00–16:00	AM3A • Spectroscopy, Microscopy, and Fiberoscopy	IM3B • Biomedical Imaging I	LM3C • Novel techniques & special applications	MM3D • Imaging in complex media	JM3E • Not Your Dentist's X-ray (COSI/AIO)	DM3F • Incoherent Holography	3M3G • Measurement I	SM3H • Sensing I
16:00–17:00	JM4A • Poster Session I and Coffee Break with Exhibitors, <i>Palms Foyer and Ballroom FGHI</i>							
17:00–18:30	AM5A • Look To The Stars	IM5B • Biomedical Imaging II	LM5C • Atmospheric & environmental monitoring I	MM5D • Inverse scattering	CM5E • Depth-resolved and turbid imaging	DM5F • Applications of DH	3M5G • HMD & Aerial Display	SM5H • Sensing II
18:30–20:00	Congress Reception, <i>Palms Ballroom E</i>							

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Agenda of Sessions — Tuesday, 26 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon/ Lime	Citron	Clementine	Mandarin	Tangerine
	AIO	IS	LACSEA	MATH/COSI	COSI	DH	3D	LS&C	pcAOP
07:00–18:30	Registration, <i>Palms Foyer</i>								
08:00–09:00	JT <u>u</u> 1A • Plenary Session II with the Light the Future Speaker Series, <i>Citron</i>								
09:00–10:00	Coffee Break with Exhibitors, <i>Palms Foyer</i>								
10:00–12:00	ATu2A • Keynote and Laser Sorcery	ITu2B • Microscopy I: Super-resolution & Illumination Techniques	LTu2C • Combustion Diagnostics I	MTu2D • High-dimensional imaging	CTu2E • Compressive sensing 1	DTu2F • Contemporary Topics in DH	3Tu2G • HMD & VAC Solution	STu2H • Components I	PTu2I • Propagation Simulations
12:00–13:30	Light the Future Lunch, <i>Palm Foyer</i>								
12:30–14:00	Student & Early Career Professional Development & Networking Lunch and Learn, <i>Jasmine</i>								
13:30–15:30	ATu3A • Fiber Sensory Overload	ITu3B • Microscopy II: 3D & High Speed Techniques (starts at 14:00)	LTu3C • Combustion diagnostics II		JTu3D • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman		3Tu3E • Compressing & Integral imaging sensing (Light Field)	STu3F • Quantum Protocols I (starts at 14:30)	PTu3G • Underwater Propagation (starts at 14:15)
15:30–16:30	JT <u>u</u> 4A • Poster Session II Coffee Break with Exhibitors, <i>Palms Foyer and Ballroom FGHI</i>								
16:30–18:30	ATu5A • Bridging Two Worlds - Academics and Industry	JTu5B • Microscopy & Imaging (IS/AO)	LTu5C • Atmospheric & environmental monitoring II	CTu5D • Compressive sensing 2: spectral imaging	JTu5E • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman	DTu5F • Computer-Generated Holograms	3Tu5G • 360-degree display and perception	STu5H • Quantum Protocols II	PTu5I • Propagation In Scattering Media
18:30–19:30	50th Anniversary of Introduction to Fourier Optics by Joseph Goodman Reception, <i>Orange/Lemon/Lime</i>								
19:00–21:00	Illumicon II, <i>A secret location</i>								

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Agenda of Sessions — Wednesday, 27 June

	Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon	Citron	Clementine	Mandarin	Tangerine	Lime
	AIO	IS/COSI	LACSEA	MATH	COSI	DH	3D	LS&C	pcAOP	AO
07:30–18:30	Registration, <i>Palms Foyer</i>									
08:00–09:00	JW1A • Plenary Session III, <i>Citron</i>									
09:00–10:00	Coffee Break with Exhibitors, <i>Palms Foyer</i>									
10:00–12:00	AW2A • You Down With OCT (Yeah You Know Me)	IW2B • Computer Vision & Image Processing	LW2C • Velocimetry, films & fundamentals	MW2D • Sparsity based priors	CW2E • Computational microscopy	DW2F • Deep Learning in DH	3W2G • Measurement II	SW2H • Quantum Protocols III	PW2I • Atmospheric Propagation	OW2J • Wavefront/ Beam Control & Sensing I
12:00–13:00	Applications of Visual Science Technical Group Networking Lunch, <i>Salon C</i>									
12:00–13:30	Lunch on your Own									
13:30–15:30	AW3A • Animal Optics: The Facts of Light	CW3B • Machine Learning in Computational Sensing and Imaging I	LW3C • Techniques for reactors, shock tubes & cells	MW3D • Application in 3D Microscopy	JW3E • Aerospace Imaging (COSI/IS)	DW3F • Multi-wavelength Digital Holography	3W3G • Light Field Display	SW3H • Components II (ends at 14:30)	PW3H • Environmental Propagation	OW3J • Wavefront/ Beam Control & Sensing II (ends at 15:00)
15:30–16:30	JW4A • Poster Session III Coffee Break with Exhibitors, <i>Palms Foyer and Ballroom FGHI</i>									
16:30–18:30	AW5A • Orlando: The New Silicon Valley?	CW5B • Machine Learning in Computational Sensing and Imaging II	LW5C • Ultra-fast techniques & high-speed imaging II	MW5D • Model-based imaging	JW5E • Spectral Imaging (COSI/IS)	DW5F • OptoFluidic and Life Applications of DH	3W5G • Interferometry & OCT			JW5I • Turbulence & Propagation (pcAOP/AO)

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Agenda of Sessions — Thursday, 28 June

	Sunset/Fleming	Siesta/Biscayne	Cedar/Marathon	Orange/Lemon/ Lime	Citron	Clementine
	AIO	Joint	DH	COSI	DH	AO
07:30–16:00	Registration, Palms Foyer					
08:00–09:00	Postdeadline Papers (schedule and location listed in the congress update sheet)					
09:00–09:45	Coffee Break with Exhibitors, Palms Foyer					
09:45–11:45	ATH2A • Another Day, Another Detector	ITh2B • Sensors & Optics	DTh2C • Digital Holographic Microscopy	CTh2D • Phase retrieval	DTh2E • Advances in DH Techniques 2	OTh2F • AO Systems II
11:45–13:30	Lunch on your Own					
13:00–18:00	Tour of Laser Propagation Facilities at Kennedy Space Center (Extra fee and advanced registration required.)					
13:30–15:30	JTh3A • Ptychography, It's Complex (AIO/COSI)	JTh3B • Holographic Microscopy (COSI/DH)		CTh3C • Imaging through aberrations, Structured illumination & super resolution	DTh3D • Integral Imaging and Holographic Displays	OTh3E • Control & Simulations
15:30–16:00	Coffee Break with Exhibitors, Palms Foyer					
16:00–18:00				CTh4A • Quantum computational imaging	DTh4B • System Design and Data Processing in DH	OTh4C • Adaptive Optics Systems for the Eye

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CALL FOR PAPERS: LACSEA 2018

Submission Opens: 1 October 2018

Submission Deadline: 1 November 2018

This Feature Issue in *Applied Optics* is based on the Laser Applications to Chemical, Security, and Environmental Analysis (LACSEA) Topical Meeting. While meeting participants are encouraged to submit their work, this Feature Issue is open to all contributions.

FEATURE ISSUE EDITORS

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Thomas Dreier, *University of Duisburg-Essen, Germany*

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Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security
and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:30 Registration, Palms Foyer

Citron

08:00–09:30

JM1A • Plenary Session I

JM1A.1 • 08:00 

Light Fields and Light Stages for Photoreal Movies, Games, and Virtual Reality, Paul Debevec, Google VR, USA. This talk will present work from USC ICT and Google VR in creating actors and environments for movies, games, and virtual reality. The Light Stage computational illumination and facial scanning systems are geodesic spheres of inward-pointing LED lights which have been used to create digital actor effects in movies such as Avatar, Benjamin Button, and Gravity, and have recently been used to create photoreal digital actors based on real people in movies such as Furious 7, Blade Runner: 2049, and Ready Player One. The lighting reproduction process of light stages allows omnidirectional lighting environments captured from the real world to be accurately reproduced in a studio, and has recently be extended with multispectral capabilities to enable LED lighting to accurately mimic the color rendition properties of daylight, incandescent, and mixed lighting environments. They have also recently used their full-body light stage in conjunction with natural language processing and automultiscopic projection to record and project interactive conversations with survivors of the World War II Holocaust. Debevec will conclude by discussing the technology and production processes behind "Welcome to Light Fields", the first downloadable virtual reality experience based on light field capture techniques which allow the visual appearance of an explorable volume of space to be recorded and reprojected photorealistically in VR enabling full 6DOF head movement.

09:30–10:30 Coffee Break with Exhibitors, Palms Foyer

10:30–12:30

AM2A • You Say LIDAR, I Say LADAR

Presider: Mark Itzler; Princeton Lightwave Inc., USA

AM2A.1 • 10:30 

Qualifying active components for Space and LIDAR applications, Thomas Laurent¹, Herwig Stange¹, Michael Kneier¹, ¹eagleyard Photonics GmbH, Germany. Nowadays Single Frequency Laser Diodes are challenged again, as they are supposed to add more functionalities prior rather realized on module or system level. Latest requirements have significant impact in defining, selecting, and qualifying components successfully with respect to their use in various applications.

10:30–12:30

IM2B • Thin Optics and Optical Design

Presider: Michael Groenert; US Army RDECOM CERDEC, USA

IM2B.1 • 10:30 

Electrically switchable large, thin, and fast optics, Nelson V. Tabiryan¹, Jeougyeon Hwang¹, Haiqing Xianyu¹, Svetlana Serak¹, Sarik Nersisyan¹, Brian Kimball², Diane Steeves², Michael McConney³, Timothy Bunning³, ¹Beam Engineering for Adv Measurements Co, USA; ²US Army Natick Soldier Research, Development & Engineering Center, USA; ³Air Force Research Labs, USA. Diffractive waveplates enable stackable ultrathin light-weight large area optics fast-switchable with low-voltage/low power fields. State-of-the-art systems and low-cost manufacturing opportunities will be presented aimed at next generation augmented, virtual reality, flexible, polarizer-free displays, LiDARs, etc.

10:30–12:30

LM2C • Ultra-fast Techniques & High-speed Imaging

Presider: Thomas Dreier; Universität Duisburg-Essen, Germany

LM2C.1 • 10:30 

Ultrashort Pulse Laser Imaging of Molecular Species, Waruna Kulatilaka¹, ¹Texas A&M Univ., USA. Broadband, femtosecond-duration laser pulses provide numerous opportunities as well as challenges in high-temperature gas-phase spectroscopy of molecular species. Several recent advances in combustion diagnostic applications along with future perspectives are discussed.

10:30–12:00

MM2D • Tomography

Presider: Bettina Heise; RECENDT, Austria

MM2D.1 • 10:30 

Quantitative Imaging with Photoacoustic and Optical Coherence Tomography, Peter Elbau¹, Leonidas Mindrinos¹, Otmar Scherzer^{1,2}, ¹Univ. of Vienna, Austria; ²Johann Radon Inst. for Computational and Applied Mathematics, Austria. We discuss a multi-modal imaging system consisting of an optical coherence tomography measurement, which we want to model as an inverse electromagnetic scattering problem, and a photoacoustic setup, where the acoustic response induced by a short laser pulse is measured and which provides us, after tracing back the pressure wave, with internal data describing the absorbed energy inside the medium. We want to show that this combination allows us to obtain a quantitative reconstruction for all the involved physical parameters.

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:30 Registration, Palms Foyer

Citron

08:00–09:30

JM1A • Plenary Session I

JM1A.1 • 08:00 **Plenary**

Light Fields and Light Stages for Photoreal Movies, Games, and Virtual Reality, Paul Debevec, Google VR, USA. This talk will present work from USC ICT and Google VR in creating actors and environments for movies, games, and virtual reality. The Light Stage computational illumination and facial scanning systems are geodesic spheres of inward-pointing LED lights which have been used to create digital actor effects in movies such as Avatar, Benjamin Button, and Gravity, and have recently been used to create photoreal digital actors based on real people in movies such as Furious 7, Blade Runner: 2049, and Ready Player One. The lighting reproduction process of light stages allows omnidirectional lighting environments captured from the real world to be accurately reproduced in a studio, and has recently be extended with multispectral capabilities to enable LED lighting to accurately mimic the color rendition properties of daylight, incandescent, and mixed lighting environments. They have also recently used their full-body light stage in conjunction with natural language processing and automultiscopic projection to record and project interactive conversations with survivors of the World War II Holocaust. Debevec will conclude by discussing the technology and production processes behind "Welcome to Light Fields", the first downloadable virtual reality experience based on light field capture techniques which allow the visual appearance of an explorable volume of space to be recorded and reprojected photorealistically in VR enabling full 6DOF head movement.

09:30–10:30 Coffee Break with Exhibitors, Palms Foyer

10:30–12:30

CM2E • Indirect and non-line-of-sight
imaging

Presider: Oliver Cossairt; Northwestern
University, USA

CM2E.1 • 10:30

Non-Line-of-Sight Imaging using Superheterodyne Interferometry, Florian Willomitzer¹, Fengqiang Li¹, Prasanna V. Rangarajan², Oliver S. Cossairt¹; ¹Northwestern Univ., USA; ²Southern Methodist Univ., USA. The paper describes an interferometric imager concept capable of recovering the shape and geometry of objects hidden from view, with a resolution that exceeds the state-of-the-art.

CM2E.2 • 10:45

Resolving Non Line-of-Sight (NLoS) motion using Speckle, Muralidhar Madabhushi Balaji¹, Aparna Viswanath¹, Prasanna V. Rangarajan¹, Duncan MacFarlane¹, Marc Christensen¹; ¹Southern Methodist Univ., USA. Motion of objects hidden from view is recovered by tracking displacements in speckle patterns produced by the coherently illuminated object. A latent image may additionally be recovered by examining spatial correlations in the speckle pattern.

10:30–12:30

DM2F • Advances in DH Techniques I

Presider: Tomasz Kozacki; Warsaw Univ. of
Tech., Poland

DM2F.1 • 10:30 **Tutorial**

Computational Microscopy for 3D Imaging, Laura Waller¹; ¹Univ. of California Berkeley, USA. This tutorial will describe new computational imaging systems that jointly design optical systems and inverse algorithms to enable 3D imaging. We will discuss microscopy and photography examples of single-shot lensless imagers consisting of only a scattering element (a diffuser) placed in front of a 2D image sensor.

10:30–12:30

3M2G • Holographic Display

Presider: Hong Hua; Univ. of Arizona, USA

3M2G.1 • 10:30 **Invited**

Optical see-through three-dimensional near-to-eye display with depth of field control, Jae-Hyeung Park¹; ¹Inha Univ., South Korea. Three-dimensional near-to-eye display using holographic optical element (HOE) is presented. The proposed system expands the eyebox using multiplexed HOE, achieves per-pixel depth of field control using computer generated hologram (CGH), and reduces the computation time by foveated CGH.

10:30–12:00

SM2H • Free Space Communications

Presider: Claudine Besson; Office Natl.
d'Etudes Rech Aerospatiales, France

SM2H.1 • 10:30 **Invited**

Correction of Atmospheric Effects on Laser Beams for sensing and communication, Karin Stein¹; ¹Fraunhofer IOSB, Germany. Environmental effects limit the performance of any electro-optical (EO) system. Tasks such as delivery of directed energy and laser communications are significantly affected by atmospheric turbulence and refraction.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security
and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

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AM2A • You Say LIDAR, I Say LADAR—Continued

AM2A. 2 • 11:00 **Invited**

Title to be Determined, Carl Jackson¹; ¹SensL, Ireland. Abstract not available

AM2A. 3 • 11:30 **Invited**

Advances in Doppler Lidar for Accurate 3D Wind Measurements, Simon Toft Sørensen¹, Matthew Warden¹, John Macarthur¹, Mark Silver², Theodore Holtom³, Craig McDonald⁴, Peter Clive⁴, Henry Bookey¹; ¹Fraunhofer Centre for Applied Photonics, UK; ²Thales UK, UK; ³Wind Farm Analytics Ltd., UK; ⁴Wood, UK. We will present results from our recent development of a multi-beam Doppler lidar system for accurate 3-dimensional wind measurements. The eye-safe all-fibre system consists of a single seed laser that is amplified in multiple stages and shared between the three emitters. Steps towards wind turbine blade integration will be outlined.

IM2B • Thin Optics and Optical Design—Continued

IM2B.2 • 11:00

Achromatic Test of Pancharatnam Phase Lens for VR/AR, Comrun Yousefzadeh¹, Afsoon Jamali¹, Colin McGinty¹, Philip Bos¹; ¹Liquid crystal Inst., Kent state Univ., USA. In this paper we provide intuitive “limits” for the power of Pancharatnam phase based lenses under which these types of devices can be considered for use with the eye and camera specifically for VR/AR applications.

IM2B.3 • 11:15

Non-local Control of a Metasurface Image, Ashley Lyons^{1,2}, Charles Altuzarra³, Guanghui Yuan⁴, Christy Simpson^{1,2}, Thomas Roger¹, Daniele Faccio^{1,2}; ¹Heriot-Watt Univ., UK; ²Univ. of Glasgow, UK; ³Texas A&M Univ., USA; ⁴Nanyang Technological Univ., Singapore. By using correlated photon pairs, we demonstrate the non-local control of single-photon images formed by a polarisation sensitive metasurface. Non-local polarisation selection of a control photon, changes the image recorded after the metasurface.

IM2B.4 • 11:30

Towards Random Metasurface based Devices, Matthieu Dupre¹, Junhee Park¹, Liyi Hsu¹, Abdoulaye Ndao¹, Boubacar Kante¹; ¹Univ. of California San Diego, USA. Using full wave simulations and a transmission matrix approach, we design and then realize random metasurface lenses with anisotropic nanorods, and show that we can obtain a diffraction limited focal spot for all polarizations.

LM2C • Ultra-fast Techniques & High-speed Imaging—Continued

LM2C.2 • 11:00

High-speed, multi-species and multi-parameters combustion imaging, Naibo Jiang¹, Sukesh Roy¹, Paul S. Hsu¹, Mikhail Slipchenko¹, Josef Felver¹, Jordi Estevadeordal², James R. Gord³; ¹Spectral Energies, LLC, USA; ²North Dakota State Univ., USA; ³Air Force Research Lab, USA. Simultaneous 10-kHz OH-PLIF/CH₂O-PLIF/PIV (Rayleigh scattering) measurements in DRL-A non-premixed flames were demonstrated using a three-leg burst-mode laser system. High-speed multi-species concentrations, heat-release rate, and flow velocity field (temperature) were measured.

LM2C.3 • 11:15

Development of a Background-Free, Broadband Absorption Method using Ultrafast Lasers: Time-Resolved Optically Gated Absorption (TOGA) Spectroscopy, Patrick S. Walsh¹, Hans U. Staufer¹, Sukesh Roy¹, James R. Gord²; ¹Spectral Energies, LLC, USA; ²Aerospace Systems Directorate, Air Force Research Lab, USA. We demonstrate a robust ultrafast-laser technique, referred to as time-resolved optically gated absorption (TOGA) spectroscopy, for acquiring broadband, background-free, single-laser-shot absorption spectra for use in combustion diagnostics.

LM2C.4 • 11:30 **Invited**

The Application of Diagnostic Techniques Utilizing Ultra-high Repetition Rate Laser in Typical Industrial Reacting Flows, Yi Gao¹, Chen Fu¹, Xiaoyuan Yang¹, Fei Qi¹; ¹Shanghai Jiao Tong Univ., UK. The paper focuses on the study of unsteady combustion phenomena such as combustion instability, fuel atomization and pollutant generation utilizing laser diagnostics, e.g. PIV, PLIF and LII based on ultra high repetition rate laser (10k-100kHz).

MM2D • Tomography—Continued

MM2D.2 • 11:00

Synthetic Schlieren Tomography of Focused Ultrasound Transducers, Aki Pulkkinen¹, Jarkko J. Leskinen¹, Aimo Tiihonen¹; ¹Univ. of Eastern Finland, Finland. Synthetic schlieren tomography is a technique for imaging of ultrasound fields based on deflection of light due to acousto-optic effect. In this work, principal physics, and pressure field estimation are described and compared with measurements.

MM2D.3 • 11:15

Tomographic reconstruction of 3D atomic potentials from intensity-only TEM measurements, David Ren¹, Michael Chen¹, Colin Ophus², Laura Waller¹; ¹Univ. of California Berkeley, USA; ²National Center for Electron Microscopy, USA. We demonstrate a tomographic Transmission Electron Microscopy (TEM) imaging modality and reconstruction algorithm that determines 3D positions of strongly scattering atoms. Our simulation-only results show that atomic potentials can be quantitatively recovered at atomic resolution from intensity-only measurements.

MM2D.4 • 11:30 **Invited**

Tomography, Radar, Holography and Lightfield imaging - different sides of the same coin, Konrad Schöbel¹, Lars Omlor¹, Tanja Teuber¹; ¹Competencies Algorithms, Carl Zeiss AG, Germany. We present a common mathematical concept underlying such diverse imaging problems as tomography, radar, holography or lightfield imaging. This allows to “translate” ideas between different communities and yields interesting future research directions.

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

CM2E • Indirect and non-line-of-sight
imaging—Continued

CM2E.3 • 11:00

Indirect Imaging Using Correlography, Aparna Viswanath¹, Prasanna V. Rangarajan¹, Duncan MacFarlane¹, Marc Christensen¹; ¹*Southern Methodist Univ., USA*. A computational imager combining ideas from correlography and phase retrieval is used to recover images of non-line-of-sight (NLoS) objects. It exploits the intrinsic roughness of real-world surfaces to indirectly illuminate NLoS objects and intercept the return.

CM2E.4 • 11:15

Micro Resolution Time-of-Flight Imaging, Fengqiang Li¹, Florian Willomitzer¹, Prasanna V. Rangarajan², Andreas Velten³, Mohit Gupta³, Oliver S. Cossairt¹; ¹*Northwestern Univ., USA*; ²*Southern Methodist Univ., USA*; ³*Univ. of Wisconsin Madison, USA*. We propose a time-of-flight imaging technique with modulation frequencies as high as 1 THz using optical superheterodyne interferometry. Our proposed system provides great flexibility in imaging range and resolution.

CM2E.5 • 11:30

Passive Non-line-of-sight Source Classification from Coherence Measurements, Andre Beckus¹, Alexandru Tamasan¹, Zhean Shen¹, Sergey Sukhov¹, Aristide Dogariu¹, George K. Atia¹; ¹*Univ. of Central Florida, USA*. We demonstrate a passive imaging approach for identifying the shape and size of a secondary source using non-line-of-sight spatial coherence measurements.

DM2F • Advances in DH Techniques I—
ContinuedDM2F.2 • 11:15 **Invited**

Multiplexed Illumination Holographic Fluorescence Imaging, Yuan Luo¹, Chen-Yen Lin¹, Hsi-Hsun Chen¹, Wei-Tang Lin¹; ¹*National Taiwan Univ., Taiwan*. Optical sectioning techniques offer three-dimensional information from organ tissues, but require individual axial planes to be imaged consecutively. We introduce active illumination, utilizing speckle or Talbot effect, and multiplexed volume holography, demonstrating three-dimensional biopsy for microscopy as well as endoscopy, without scanning.

3M2G • Holographic Display—Continued

3M2G.2 • 11:00 **Invited**

Color dynamic holographic display by complex amplitude modulation, Juan Liu¹; ¹*Beijing Inst. of Technology, China*. An improved method of complex amplitude modulation (CAM) is proposed for color dynamic holographic display with a wide viewing angle. Bandlimited random initial phase is introduced to enlarge the field of view for 3D display.

3M2G.3 • 11:30 **Invited**

Holographic Goggles for Near Infrared Fluorescence Image Guided Surgery, Viktor Gruev¹; ¹*Univ. of Illinois, USA*. Abstract not available

SM2H • Free Space Communications—
Continued

SM2H.2 • 11:00

Atmospheric turbulence on pointing errors of free space optical communication link, Siyuan Yu^{1,2}, Lifang Li^{3,4}, Pengzhen Guo^{1,2}, Qingbo Yang^{1,2}, Liying Tan^{1,2}, Jing Ma^{1,2}; ¹*National Key Lab of Tunable Laser Tech., China*; ²*Aerospace, Harbin Inst. of Tech., China*; ³*Electrical and Mechanical College, Lab for Space Environment and Physical Sciences, China*; ⁴*Electrical and Mechanical College, Harbin Inst. of Tech., China*. We have established a compensation model between atmospheric turbulence and pointing errors, which can provide quantitative analysis of atmosphere turbulence on pointing angle errors of PAT system.

SM2H.3 • 11:15

Free Space Optical Communication System through Turbid Media with Pointing Errors, Sunil Kumar K^{1,2}, Satheesh S K^{1,3}, Ilavazhagan G⁴, Krishna Moorthy K¹; ¹*Centre for Atmospheric and Oceanic Sciences, Indian Inst. of Science, India*; ²*Electronics and Communication Engineering, Hindustan Inst. of Tech. & Science, India*; ³*Divecha Centre for Climate Change, Indian Inst. of Science, India*; ⁴*Centre for Photonics and LIDAR Research, Hindustan Inst. of Tech. & Science, India*. A seven channel Aethalometer measured Black carbon (BC) and Optical Properties of Aerosols and Clouds (OPAC) aerosol model based study shows a transmitter power penalty of 3dB for a DPSK Free Space Optical Communication System (FSOC).

SM2H.4 • 11:30

Increase Data Rate of OLED VLC System Using Pre-Emphasis Circuit and FBMC Modulation, Quang Thai Pham¹, François Rottenberg², Dat T. Pham³, Shimamoto Shigeru⁴; ¹*HoChiMinh city Univ. of Technology, Viet Nam*; ²*Université catholique de Louvain, ICTEAM Inst., Belgium*; ³*National Inst. of Information and Communications Technology, Japan*; ⁴*Dept. of Communications and Computer Inst., Waseda Univ., Japan*. Using a commercial organic light emitting diode (OLED) with 7 kHz modulation bandwidth, we was able to achieve 2 Mbps transmission data rate using a combination of active pre-equalizer and Filter Bank Multi-Carrier (FBMC) modulation.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security
and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AM2A • You Say LIDAR, I Say LADAR—Continued

AM2A. 4 • 12:00

Time-Domain Compressive FMCW LADAR, Bryan T. Bosworth¹, Charbel Rizk¹, Mark Foster¹; ¹*Johns Hopkins Univ., USA*. We demonstrate a straightforward modification of FMCW LADAR to permit measurement of beat notes well beyond the receiver bandwidth using <0.5% of Nyquist sampling while achieving picowatt minimum sensitivity.

AM2A. 5 • 12:15

Compressive Time-of-Flight Imaging, Fengqiang Li¹, Huaijin Chen², Chia-Kai Yeh¹, Adithya Pediredla², Kuan He¹, Ashok Veeraghavan¹, Oliver S. Cossairt¹; ¹*Northwestern Univ., USA*; ²*Rice Univ., USA*. We propose an imaging architecture to achieve high spatial resolution ToF imaging via optical multiplexing and compressive sensing. We developed a prototype 1-megapixel compressive ToF camera that achieves as much as 4x improvement in spatial resolution.

IM2B • Thin Optics and Optical Design—Continued

IM2B.5 • 11:45

Reflective Microwave Ghost Imaging With Dynamic Metasurface Apertures, Aaron V. Diebold¹, Mohamadreza F. Imani¹, Timothy Sleasman¹, David Smith¹; ¹*Duke Univ., USA*. We demonstrate phaseless, single-frequency ghost imaging at microwave frequencies using a dynamic metasurface aperture. This aperture comprises a simplified hardware architecture for generating diverse speckle patterns by tuning an array of resonant metamaterial elements.

IM2B.6 • 12:00

The Proton Beam Imaging System Design for the Spallation Neutron Source Tungsten Target, Abdu-rahim Rakhman¹, Willem Blokland¹, Slobodan Rajic¹, Mark Rennich¹; ¹*Oak Ridge National Lab, USA*. A periscope based remote imaging system has been developed to for an in-situ viewing of high-energy proton beams on the rotating tungsten target in harsh radiation environment at the Spallation Neutron Source. The optical system design and the performance of a prototype system will be presented.

IM2B.7 • 12:15

Encoding Optical Architectures via Gene Expression Programming, Colin C. Olson¹; ¹*Naval Research Lab, USA*. We introduce a methodology for encoding optical architectures (i.e., number, types, and order of optical elements) that enables automated design of optical systems when combined with ray tracing software, parameter optimizations, and a merit function.

LM2C • Ultra-fast Techniques & High-speed Imaging—Continued

LM2C.5 • 12:00

High-speed Tomo-PIV/OH-PLIF Measurements of a Transverse Turbulent Reacting Fuel Jet, Tongxun Yi¹; ¹*Spectral Energies, LLC, USA*. High-speed tomographic PIV measurements synchronized with OH-PLIF imaging are used to fully resolve the nine-component velocity-gradient tensor upstream of a turbulent flame front, which is not possible with the traditional stereo-PIV/PLIF technique.

LM2C.6 • 12:15

Hydrogen Femtosecond Vibrational CARS Thermometry in Solid Propellant Flames, Daniel R. Richardson¹, Marley Kunzler¹, Daniel R. Gueldenbecher¹; ¹*Sandia National Labs, USA*. Femtosecond coherent anti-Stokes Raman scattering thermometry in a solid-fuel propellant flame is demonstrated by tuning the lasers to the rovibrational Raman transitions of diatomic hydrogen (H₂).

MM2D • Tomography—Continued

MM2D.5 • 12:00

CNN based Sinogram Denoising for Low-Dose CT, Muhammad Usman Ghani¹, Clem Karl¹; ¹*Boston Univ., USA*. Reduction of source flux results in an increase of noise in data sinograms, which subsequently produces artifacts in the corresponded reconstructed images. We use deep-learning to denoise the original sinograms, resulting in higher quality images.

MM2D.6 • 12:15

Spectral Encoding using k-space/frequency Duality, Hichem Guerboukha¹, Kathirvel Nallappan¹, Maksim Skorobogatyi¹; ¹*Ecole Polytechnique de Montreal, Canada*. Single-pixel imaging has recently attracted a lot of attention. Here, we propose to use spectral encoding in a single-pixel detection scheme. We demonstrate the reconstruction process for amplitude and phase masks and we study the resolution.

12:30–14:00 Lunch on your Own

12:30–14:00 Digital Holographic Microscopy: Present and Future Panel Discussion, *Salon C*

Orange/Lemon/Lime

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Application of Lasers for Sensing & Free
Space Communication

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CM2E • Indirect and non-line-of-sight
imaging—Continued

CM2E.6 • 11:45

Diffuse Time-of-flight Imaging with a Single-Photon Camera, Ashley Lyons^{1,2}, Alessandro Boccolini¹, Audrey Repetti¹, Francesco Tonolini¹, Zhouye Chen¹, Jonathan Leach¹, Robert Henderson³, Yves Wiaux¹, Daniele Faccio^{1,2}; ¹Heriot-Watt Univ., UK; ²School of Physics and Astronomy, Univ. of Glasgow, UK; ³Univ. of Edinburgh, UK. The spatial and temporal photon arrival time information is used to perform imaging through diffusive media. Increasing the spatial and/or temporal resolution increases the final image resolution.

CM2E.7 • 12:00

Imaging with Phasor Fields for Non-Line-of Sight Applications, Syed A. Reza¹, Marco A. La Manna¹, Andreas Velten¹; ¹Univ. of Wisconsin-Madison, USA. A mathematical construct 'Phasor Fields' (P-Fields) is used to develop a light transport mathematical model for non-line-of-sight (NLOS) imaging applications. We show that NLOS imaging can be treated as conventional line-of-sight (LOS) imaging using P-Fields.

CM2E.8 • 12:15

Indirect Imaging Using Virtualized Pattern Projection, Aparna Viswanath¹, Muralidhar Madabhushi Balaji¹, Prasanna V. Rangarajan¹, Duncan MacFarlane¹, Marc Christensen¹; ¹Southern Methodist Univ., USA. The submission examines the role of illumination diversity in recovering shape, texture and motion of objects hidden from view. Focused spots incident on a scattering wall are used to spatially pattern the illumination within the hidden volume.

DM2F • Advances in DH Techniques I—
Continued

DM2F.3 • 11:45

Simultaneous Angular Acquisition in Quantitative Phase Microscopy Using Off-Axis Hologram Multiplexing, Natan T. Shaked¹, Gyanendra Singh¹; ¹Tel-Aviv Univ., Israel. We present a new technique for multiplexing multiple angular perspectives into a single off-axis hologram, which is useful for tomography, super resolution, and stereoscopy.

DM2F.4 • 12:00

Achieving Fast 3D Label-free Microscopy for Optical Tweezers Experiments, Juan M. Soto¹, Jose A. Rodrigo¹, Tatiana Alieva¹; ¹Dept. of Optics, Complutense Univ. of Madrid, Spain. We present a technique exploiting partially coherent light and a system compatible with widefield microscopes that allows achieving label-free dynamic 3D quantitative imaging of live cells simultaneously manipulated by optical tweezers.

DM2F.5 • 12:15

Digital Plasmonic Holography, Joseph Nelson¹, Greta Knefelkamp¹, Alexandre Brolo², Nathan Lindquist¹; ¹Bethel Univ., USA; ²Univ. of Victoria, Canada. Direct two-dimensional imaging with surface plasmons suffers from the lack of simple two-dimensional lenses. Here we show that digital holographic microscopy techniques can be used for lens-less in-plane surface imaging with propagating plasmons.

3M2G • Holographic Display—Continued

3M2G.4 • 12:00

Near-eye foveated holographic display, Jisoo Hong¹, Youngmin Kim¹, Sunghee Hong¹, Choonsung Shin¹, Hoonjong Kang¹; ¹VR/AR research center, Korea Electronics Technology Inst., South Korea. Holographic and two-dimensional displays can be combined at the angular spectrum domain to provide three-dimensional image near fovea and two-dimensional image for periphery. This scheme can resolve vergence-accommodation conflict of the near-eye display.

3M2G.5 • 12:15

Numerical correction of image distortion in CGH display based on automatic calibration algorithm, Liangcai Cao¹, Zehao He¹, Guofan Jin¹; ¹Tsinghua Univ., China. A numerical correction method of image distortion for computer generated holography (CGH) display is proposed. A camera-based wavefront sensing system is proposed with the designed CGH testing images. The automatic pre-calibration algorithm is developed.

SM2H • Free Space Communications—
Continued

SM2H.5 • 11:45

Applications of Lasers for Sensing and Free Space Communication, Mohammed S. S.; ¹St. Joseph's College of Engineering, India. This article gives an overview of the challenges a designer has to consider while implementing the Free Space Communication System using laser and how it's applied in various fields and the modulations schemes used in detail. Advantages of FSO result from the basic characteristics of laser beam, especially from its high frequency, coherence and low divergence, which lead to efficient delivery of power to a receiver and a high information carrying capacity.

12:30–14:00 Lunch on your Own

12:30–14:00 Digital Holographic Microscopy: Present and Future Panel Discussion, Salon C

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

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Cedar/Marathon

Mathematics in Imaging

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14:00–16:00

AM3A • Spectroscopy, Microscopy, and Fiberosecopy

Presider: Brandon Redding; US Naval Research Lab, USA

AM3A.1 • 14:00 **Invited**

A Spectroscopic Method to Determine Color of Petroleum Products, John D. Rodriguez², Matthew Comstock², Dieter Bingemann¹, Ty Olmstead²; ¹*Ocean Optics BV, Germany*; ²*Ocean Optics Inc, USA*. Color is an important metric for determining the quality of petroleum products. The spectroscopic method described in this paper yields results on actual gasoline samples that are accurate and repeatable

AM3A.2 • 14:30

High-precision wavelength modulation - direction absorption spectroscopy, Yanjun Du¹, Yanjun Ding¹, Zhimin Peng¹; ¹*Tsinghua Univ., China*. Wavelength modulation - direct absorption spectroscopy (WM-DAS) is proposed by extracting the characteristic spectrum. This method improves the accuracy of the absorbance profile measurement by one order of magnitude and is verified by experiments.

AM3A.3 • 14:45

Handheld, Quantitative, Standoff Methane Detector and Imager, Richard T. Wainner¹, Nicholas F. Aubut¹, Matthew Laderer¹, Shin-Juh Chen¹, Mickey B. Frish¹; ¹*Physical Sciences Inc., USA*. Addressing the needs of upstream natural gas infrastructure, using an adaptation of handheld remote laser sensing tools, we demonstrate sensitive quantified methane leak imaging and flux estimation.

14:00–16:00

IM3B • Biomedical Imaging I

Presider: Kevin Gemp; The MITRE Corporation, USA

IM3B.1 • 14:00 **Invited**

Ultra-High Resolution Full-Field OCT (FFOCT) for Cornea and Retina, Claude A. Boccara¹, Viacheslav C. Mazlin¹, Peng C. Xiao¹, Jules C. Scholler¹, Kate C. Grieve², Kristina Irsch², José-Alain Sahel², Mathias Fink¹; ¹*Institut Langevin, France*; ²*HOPITAL 15_20, France*. Full-field Optical Coherence Tomography (FFOCT) offers aberration independent resolution. This property is particularly useful for eye imaging, as micrometer features are visible without adaptive optics (AO). Diffraction-limited *in vivo* corneal and retinal images are demonstrated.

IM3B.2 • 14:30

Rapid full-field optical coherence tomography using geometric phase ferroelectric liquid crystal technology, Maitreyee . Roy¹, Zheng Wei², Colin Sheppard³; ¹*Univ. of New South Wales, Australia*; ²*Dept. of Biomedical Engineering, National Univ. of Singapore, Singapore*; ³*Dept. of Nanophysics, Istituto Italiano di Tecnologia, Italy*. We demonstrate a fast, switchable achromatic phase shifter operating on the geometric phase principle, using ferroelectric liquid crystal technology for rapid 3D biological imaging in a full field optical coherence tomography system.

IM3B.3 • 14:45

Automated Image Processing Algorithm for Infrared Meibography, Clara Llorens Quintana¹, Piotr Syga², D. Robert Iskander¹; ¹*Biomedical Engineering, Wrocław Univ. of Science and Technology, Poland*; ²*Computer Science, Wrocław Univ. of Science and Technology, Poland*. Infrared meibography is a technique for imaging meibomian glands that are located in the rim of the eyelids. An automated methodology for analysing these images was proposed to assess meibomian glands structure and health.

14:00–16:00

LM3C • Novel Techniques & Special Applications

Presider: Paul Hsu; Spectral Energies LLC, USA

LM3C.1 • 14:00 **Invited**

Towards an all-purpose laser excitation tool for multimodal nonlinear microscopy, Niklas Müller¹, Lukas Brückner¹, Marcus . Motzkus¹; ¹*Ruprecht-Karls-Universität Heidelberg, Germany*. We present combined mid-infrared and nonlinear Raman spectroscopy in a single beam setup exploiting spectral focussing and sub 10 fs pulse shaping.

LM3C.2 • 14:30

Four-Dimensional X-ray Imaging of Multiphase Flows, Benjamin R. Halls¹, Naveed Rahman², Terrence Meyer², Malissa Lightfoot³, Mikhail Slipchenko^{2,4}, Sukesh Roy⁴, James R. Gord¹; ¹*Air Force Research Lab, USA*; ²*Purdue Univ., USA*; ³*Air Force Research Lab, USA*; ⁴*Spectral Energies, LLC, USA*. Four-dimensional x-ray measurements are demonstrated in an optically complex spray using three x-ray sources and three high-speed imaging systems. Time-evolving volumes are reconstructed from the quantitative two-dimensional path length data.

LM3C.3 • 14:45

Diode Laser Based Film Thickness Measurement of DEF, Anna K. Schmidt^{1,2}, Benjamin Kühnreich^{1,2}, Hannah Kittel³, Cameron Tropea³, Ilia Roisman³, Andreas Dreizler², Steven Wagner^{1,2}; ¹*High Temperature Process Diagnostics, Germany*; ²*Reactive Flows and diagnostics, Germany*; ³*Fluid Mechanics and Aerodynamics, Germany*. An absorption based laser sensor for the investigation of liquid film thicknesses of DEF is presented. A wavelength pre-selection ensures that film thicknesses could be measured without cross sensitivity to temperature or concentration.

14:00–15:45

MM3D • Imaging In Complex Media

Presider: John Schotland; Univ. of Michigan, USA

MM3D.1 • 14:00 **Invited**

Correlation-based imaging in random media, Josselin Garnier¹; ¹*Ecole Polytechnique, France*. In the white-noise paraxial regime wave propagation in random media can be modeled by a Schrodinger-type equation driven by a Brownian field. Correlation-based imaging methods can then be characterized in terms of resolution and stability.

MM3D.2 • 14:30

First Born Model for Reflection-Mode Fourier Ptychographic Microscopy, Alex C. Matlock¹, Anne Sentenac², Ji Yi³, Lei Tian¹; ¹*Boston Univ., USA*; ²*Institut Fresnel - CNRS, France*; ³*Medicine, Boston Univ. School of Medicine, USA*. We validate a first Born approximation based model for Reflection-mode Fourier ptychography under the semi-infinite boundary condition. Our model enables optical thickness and absorption recovery with enhanced resolution from thin samples.

MM3D.3 • 14:45

Withdrawn

Orange/Lemon/Lime

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14:00–16:00

JM3E • Not Your Dentist's X-ray (COSI/AIO)

Presider: Andrew Harvey; Univ. of Glasgow, UK

JM3E.1 • 14:00 **Invited**

X-ray imaging based on coherence engineering as a multi-scale material characterization tool, Yunhui Zhu¹; ¹Virginia Tech, USA. Quantitative X-ray imaging based on phase-space engineering has significantly extended the data acquisition space, which enables enhanced contrast, higher sensitivity, and simultaneous characterization of complex material structures across multiple length scales.

JM3E.2 • 14:30 **Invited**

Recent Developments in X-ray Computed Tomography, Philipp Hoelzer¹; ¹Siemens Medical Solutions, Inc., USA. This talk presents concepts of computed tomography in terms of image acquisition, reconstruction and analysis, and outlines some recent technology developments.

14:00–16:00

DM3F • Incoherent Holography

Presider: Konstantinos Falaggis; Univ. of North Carolina at Charlotte, USA

DM3F.1 • 14:00 **Invited**

Switchable, broadband, polarization-independent diffractive optical components and systems, David E. Roberts¹, Nelson V. Tabiryan¹, Michael McConney², Timothy Bunning²; ¹BEAM Engineering for Adv. Measurements, USA; ²Air Force Research Labs, USA. Devices based on diffractive waveplates exhibit diffraction characteristics that are dependent on the polarization and wavelength of light. In applications, switchability, polarization independence, and wavelength independence are often desirable. Here we report on recent developments of diffractive optical elements that have various combinations of switchability, polarization independence, and broad wavelength coverage.

DM3F.2 • 14:30 **Invited**

Adaptive Fluorescence Digital Holographic Imaging, Yuhong Wan¹, Tianlong Man¹, Hongqiang Zhou¹, Dayong Wang¹; ¹Beijing Univ. of Technology, China. Fluorescence self-interference holographic microscopy combined with computational adaptive optics are demonstrated, thus the imaging performances of the technology are improved with less recording time, anisotropic aberration correction and improved imaging resolution.

14:00–16:00

3M3G • Measurement I

Presider: Osamu Matoba; Kobe Univ., Japan

3M3G.1 • 14:00 **Invited**

Single-Shot Phase Imaging with Coded Diffraction and Its Applications, Ryoichi Horisaki^{1,2}; ¹Osaka Univ., Japan; ²JST, PRESTO, Japan. We have presented single-shot quantitative phase imaging with a coded aperture or structured illumination based on compressive sensing. It enables to remove the reference light and increase the field-of-view which are fundamental issues in digital holography and phase retrieval.

3M3G.2 • 14:30

High Resolution Single-Shot 3D Imaging with the "3D movie camera", Florian Willomitzer¹, Gerd Häusler²; ¹Northwestern Univ., USA; ²Univ. Erlangen-Nuremberg, Germany. We introduce a novel sensor for the 3D acquisition of macroscopic live scenes. The sensor combines single-shot acquisition with a precision and point cloud density close to the theoretical maximum.

3M3G.3 • 14:45

Structured Light Imaging under Sunlight Conditions, Jostein Thorstensen¹, Jon Tschudi¹, Karl Henrik Haugholt¹, Gregory Bouquet¹, Trine Kirkhus¹; ¹Smart Sensor Systems, SINTEF, Norway. We demonstrate a Structured Light Imaging system that provides Mpix resolution images with sub-mm depth precision at 1 m distance, when operating in direct sunlight. This is achieved through spectral filtering of the camera and the use of a high power VCSEL. We discuss predicted and observed precision.

14:00–16:00

SM3H • Sensing I

Presider: Karin Stein; Fraunhofer IOSB, Germany

SM3H.1 • 14:00 **Invited**

New developments in active sensing at ONERA, Claudine Besson¹; ¹ONERA, France. The paper presents some of the technology maturing activity on gas sensing and active imaging at ONERA along with the development of tools and methods for optical sensors performance assessment.

SM3H.2 • 14:30 **Invited**

Novel Development for FMCW Lidar, Patrick Feneyrou¹, Luc Leviandier¹, Jean Minet², Grégoire Pillet³, Aude Martin¹, Daniel Dolfi¹, Jean-Pierre Schlotterbeck⁴, Philippe Rondeau⁴, Xavier Lacondemine⁴, Alain Rieu⁵, Thierry Midavaine⁵; ¹Thales Research and Technology France, France; ²Koheron, France; ³Thales DMS France, France; ⁴Thales AVS France, France; ⁵Thales LAS France, France. Frequency-modulated continuous-wave lidar is evaluated for laser anemometry for helicopter, range finding and velocimetry at long range. Optimized signal processing is described as well as demonstration of range-finding/velocimetry from a few meters up to 10 km.

Sunset/Fleming

Applied Industrial Optics

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AM3A • Spectroscopy, Microscopy, and
Fiberscopy—Continued

AM3A.4 • 15:00

Uniform Angular Illumination in Optical Microscopes, Ravikiran Attota¹, Emil Agocs¹; ¹Nanoscale Metrology, NIST, USA. Angular illumination asymmetry (ANILAS) at the sample plane depends on illumination wavelength, objective type and the location of aperture stop. To extract consistent and accurate quantitative values, all the three parameters must be aligned.

AM3A.5 • 15:15 **Invited**

Path to new optical components using CO2 splicing technologies, Erik Bottcher¹; ¹NYFORS, Sweden. CO2 lasers are becoming increasingly popular for fiber processing. Due to the short absorption length of 10,6 μm light in glass, a very localized heating in the component can be achieved. But this localized heating is not only advantageous in traditional fiber splicing. By controlling the shape and angle of the light new fiber components can be manufactured.

IM3B • Biomedical Imaging I—Continued

IM3B.4 • 15:00 **Invited**

Integrating Retinal Birefringence Scanning and Optical Coherence Tomography for Pediatric Retinal Imaging, Boris I. Gramatikov¹, Kristina Irsch¹, David L. Guyton¹; ¹Wilmer Eye Inst., Johns Hopkins Univ., USA. A hybrid system integrating Optical Coherence Tomography and Retinal Birefringence Scanning acquires and/or analyzes data only during central fixation. This can lead to significant acceleration of the image processing phase, and shorten the exam duration.

IM3B.5 • 15:30 **Invited**

Adaptive electrowetting optical devices for imaging, Juliet T. Gopinath¹, Robert H. Cormack¹, Gregory L. Futia², Connor McCullough², Philip D. Nystrom³, Baris N. Ozbay², Wei Y. Lim³, Omkar D. Supekar³, Mo Zohrabi¹, Emily A. Gibson², Diego Restrepo⁴, Victor M. Bright³; ¹Electrical, Computer and Energy Engineering, Univ. of Colorado Boulder, USA; ²Bioengineering, Univ. of Colorado Denver Anschutz Medical Campus, USA; ³Mechanical Engineering, Univ. of Colorado Boulder, USA; ⁴Developmental and Cell Biology, Univ. of Colorado Denver Anschutz Medical Campus, USA. Electrowetting adaptive optical devices are compact, high quality, versatile, and consume very low amounts of power. We demonstrate these elements for non-mechanical beam scanning in a two-photon microscope and show imaging of mouse hippocampal neurons.

LM3C • Novel Techniques & Special
Applications—ContinuedLM3C.4 • 15:00 **Invited**

PIVOTS: A novel method of performing time gated particle image velocimetry, Megan Paciaroni¹, Yi Chen², Daniel R. Guildenbecher², Kyle Lynch²; ¹Physics & Engineering, Fort Lewis College, USA; ²Sandia National Labs, USA. Backscatter Particle Image Velocimetry via Optical Time-of-flight Sectioning (PIVOTS) is a novel method of performing PIV in situations where conventional PIV presents difficulties. The PIVOTS technique is introduced along with recent applications and results.

LM3C.5 • 15:30

Analysis of the Laser-Induced Ignition Spark for Cryogenic Rocket Combustion, Robert G. Stützer¹, Michael Börner¹, Michael Oswald¹; ¹Inst. of Space Propulsion, German Aerospace Center (DLR), Germany. Laser ignition was applied on a cryogenic rocket combustor. The induced plasma breakdown was analyzed using spectroscopic (LIBS) and other optical methods. Hence, plasma temperature, localized equivalence ratio and the exact ignition time were determined.

MM3D • Imaging In Complex Media—
ContinuedMM3D.4 • 15:00 **Invited**

Seeing Inside and Beyond: Challenges and Trends in (Low) Coherent Imaging, Bettina Heise^{1,2}; ¹Optics, Research Center for Nondestructive Testing (RECENDT), Austria; ²Engineering and Natural Sciences Fac., Johannes Kepler Univ. (JKU), Austria. In this paper we review developments in (low) coherent imaging with respect to optical and mathematical concepts and realizations. In particular novel light sources, SLM-based controlling of wavefronts, and advanced reconstruction point towards future solutions.

MM3D.5 • 15:30

Simultaneous Measurement and Reconstruction Tailoring for Phase Imaging, Zhengyun Zhang¹, Wei-Na Li¹, Anand Asundi², George Barbastathis^{1,3}; ¹Singapore-MIT Alliance for Res & Tech Ct, Singapore; ²School of Mechanical and Aerospace Engineering, Nanyang Technological Univ., Singapore; ³Dept. of Mechanical Engineering, MIT, USA. We propose a joint optimization approach to phase imaging, wherein instead of separately designing the measurement process and reconstruction method, we use convex optimization to find an optimal measurement-reconstruction pair minimizing expected reconstruction error.

Orange/Lemon/Lime

Joint Computational Optical Sensing and Imaging/Applied Industrial Optics

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

JM3E • Not Your Dentist's X-ray (COSI/AIO)—Continued

JM3E.3 • 15:00 **Invited**

3D Imaging on the Nanoscale via X-ray Ptychography, Esther H. Tsai¹, Mirko Holler¹, Manuel Guizar-Sicairos¹; ¹Paul Scherrer Inst., Switzerland. From the discovery of physiological-relevant features in bulk frozen-hydrated tissues to tracking morphological changes in energy materials, ptychographic tomography has enabled the 3D characterization of various materials with an unparalleled resolution in hard X-ray imaging. Current status and challenges will be discussed.

JM3E.4 • 15:30

High Resolution Ptychographic Coherent Diffractive Imaging using Table-top XUV Sources, Wilhelm Eschen², Getnet K. Tadesse^{1,2}, Robert Klas^{1,2}, Maxim Tschernajew², Frederik Tuitje^{1,3}, Christian Spielmann^{1,3}, Andreas Tünnermann^{2,4}, Jens Limpert^{1,2}, Jan Rothhardt^{1,2}; ¹Helmholtz Inst. Jena, Germany; ²Inst. of Applied Physics, Friedrich-Schiller-Univ. Jena, Germany; ³Inst. of Optics and Quantum Electronics, Friedrich-Schiller-Univ. Jena, Germany; ⁴Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We present a coherent imaging setup for extended samples achieving record-high resolution for non-periodic samples. A Siemens star pattern is imaged and the Rayleigh criterion is used to provide a reliable sub-50 nm resolution claim.

DM3F • Incoherent Holography—Continued

DM3F.3 • 15:00

Far-Field Imaging by Annular Phase Coded Apertures, Angika Bulbul¹, Vijayakumar A¹, Joseph Rosen¹; ¹Ben Gurion Univ. of the Negev, Israel. We present a partial aperture imaging system with annular phase coded masks. The principle of interferenceless coded aperture correlation holography for 3D imaging is applied using only a small fraction of the aperture area.

DM3F.4 • 15:15

Interferenceless Coded Aperture Correlation Holography with Single Shot Recording and Non-Linear Reconstructing, Mani R. Rai¹, Vijayakumar A¹, Joseph Rosen¹; ¹Ben Gurion Univ., Israel. A non-linear computer reconstruction technique is developed for reconstructing 3D images from a single camera shot. The technique is demonstrated on a recently developed digital holography technique called interferenceless coded aperture correlation holography.

DM3F.5 • 15:30

Extending the Field of View by a Scattering Window, Mani R. Rai¹, Vijayakumar A¹, Joseph Rosen¹; ¹Ben Gurion Univ., Israel. We demonstrate a technique to extend the field of view of the interferenceless coded aperture correlation holography (I-COACH) system beyond the limit imposed by the finite area of the image sensor.

3M3G • Measurement I—Continued

3M3G.4 • 15:00

Grid-based oneshot scan using dot-line pattern, Hiroshi Kawasaki¹, Ryo Furukawa²; ¹Kyushu Univ., Japan; ²Hiroshima City Univ., Japan. Grid-based Oneshot scanning technique which is robust to sub-surface scattering is proposed. The pattern consists of parallel lines, where dotted lines and solid lines are alternatively aligned. Real objects are scanned to prove the effectiveness.

3M3G.5 • 15:15

Evaluating the Influence of Camera and Projector Lens Distortion in 3D Reconstruction Quality for Fringe Projection Profilometry, Andres G. Marrugo¹, Raul Vargas¹, Jesus Pineda¹, Jaime Meneses², Lenny A. Romero³; ¹Facultad de Ingenieria, Universidad Tecnologica de Bolivar, Colombia; ²Grupo de Óptica y Tratamiento de Señales, Universidad Industrial de Santander, Colombia; ³Facultad de Ciencias Basicas, Universidad Tecnologica de Bolivar, Colombia. We study the influence of geometric distortions of the camera and projector lenses on 3D reconstruction quality for fringe projection profilometry. Experimental results on real objects and their 3D models show the accuracy is improved.

3M3G.6 • 15:30

Hyperspectral + Depth Imaging Using Compressive Sensing and Structured Light, Elkin D. Diaz¹, Jaime Meneses¹, Henry Arguello¹; ¹Universidad Industrial de Santander, Colombia. This work presents a new CASSI setup to capture the depth and spectral information of a scene using structured light and compressive sensing. The traditional sensor in structured light acquisition is replaced by a CASSI camera.

SM3H • Sensing I—Continued

SM3H.3 • 15:00 **Invited**

Automotive LiDAR with short-wave infrared Geiger-mode detectors, Mark A. Itzler²; ²Argo AI, LLC, USA. We describe potentially disruptive automotive LiDAR performance essential to future autonomous vehicle navigation enabled by the combination of two factors: single-photon sensitivity and greater eye-safety of lasers at wavelengths beyond 1400 nm.

SM3H.4 • 15:30

Photon Counting Panoramic 3D-imaging, Markus N. Henriksson¹, Lars Allard¹, per jonsson¹; ¹Swedish Defence Research Agency, Sweden. Panoramic 3D imaging with a Gm-APD array detector over 300 m distance in daylight conditions is demonstrated. Panorama acquisition of 128 rows×350 columns/second is achieved limited by laser pulse energy and background light.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security
and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

**AM3A • Spectroscopy, Microscopy, and
Fiberoscopy—Continued**

IM3B • Biomedical Imaging I—Continued

**LM3C • Novel Techniques & Special
Applications—Continued**

**MM3D • Imaging In Complex Media—
Continued**

LM3C.6 • 15:45

Two Dimensional Scanning System for Surface Analysis of Solids Based on Laser-induced Charge Effect, Ognyan Ivanov¹, Viktor Pulis¹, Stefan I. Karatodorov¹, José Luis Pérez Díaz²; ¹*Inst. of Solid State Physics, Bulgaria;* ²*Escuela Politécnica Superior, Universidad de Alcalá, Spain.* An automated two-dimensional scanning system for express, contactless and non-destructing analysis of nonhomogeneous points on solid surfaces is presented. The system performance, based on a sensor for laser-induced surface photo charge effect, is demonstrated.

16:00–17:00 Coffee Break with Exhibitors, Palms Foyer

Salon FGH1

16:00–17:00

JM4A • Poster Session I

JM4A.1

Optofluidic Microscopy by Wavefront Division Holographic Interferometer on Chip, Biagio Mandracchia¹, Vittorio Bianco¹, Melania Paturzo¹, Pietro Ferraro¹; ¹*Inst. of Applied Sciences and Intelligent Systems, Italy.* We embed coherent imaging functionalities onboard a pocket Lab-on-a-Chip device. A pocket module that allows performing off-axis Digital Holography microscopy with no need for an interferometer setup is designed and tested for the scope.

JM4A.2

Detection of Blood Glucose Level in Mice using Ultrasonic-assisted Mid-infrared Fourier Spectroscopy for realizing Earring-type Non-invasive Blood Glucose Sensors, Natsumi Kawashima¹, Tomoya Kitazaki¹, Hiroyuki NOMURA¹, Akira NISHIYAMA¹, Kenji WADA¹, Ichiro ISHIMARU¹; ¹*Kagawa Univ., Japan.* A non-invasive, ultrasonic-assisted mid-infrared Fourier spectroscopy method to determine blood glucose levels in mice is proposed, which can be installed into smartphones. This technique is shown to depend on the time when measurements are recorded.

JM4A.3

Quantum Cascade Laser-based Optical Monitoring of N₂O₅ in a Nocturnal Tropospheric Chemical Reaction Process in an Atmospheric Simulation Chamber, Weidong Chen¹; ¹*Universite du Littoral, France.* A spectroscopic instrument based on an external cavity quantum cascade laser was developed for optical monitoring of dinitrogen pentoxide (N₂O₅) at the ppbv-level in a nocturnal tropospheric chemical reaction process in an atmospheric simulation chamber.

JM4A.4

Design of 3D Stochastic Electromagnetic Sources, Olga . Korotkova¹; ¹*Univ. of Miami, USA.* The possibilities for mathematical modeling of various classes of 3D EM stationary sources are elucidated. The special cases of uniform and non-uniform correlations, twisting, electromagnetic isotropy/anisotropy are presented.

JM4A.5

Fast and Precise Method for Measurement and Compensation of Aberrations in Spatial Light Modulator Based Holographic Projection, Jan Bolek¹, Michal Makowski¹; ¹*Faculty of Physics, Warsaw Univ. of Technology, Poland.* We present a new method for correcting aberrations in spatial light modulator based holographic projection systems. The proposed method provides precise retrieval of aberration mask. Results showing significant impact on hologram reconstruction quality are presented.

JM4A.6

Polarization-Interference 3D Holographic Tomography of Optical Anisotropy of Biological Fluids Polycrystalline Films, Igor Panko¹; ¹*Chernivtsi National Univ., Ukraine.* Our work is aimed at the development and experimental testing of Mueller-matrix digital holographic mapping method for reconstruction of the distribution of optical anisotropy parameters of partially depolarizing films of various biological fluids and the determination of objective criteria for the differentiation of polycrystalline blood films of healthy donors and patients with prostate cancer.

JM4A.7

HD Image Quality Light-field Display Architecture for Interactive-Tabletop Display Systems, Wongun Jang¹; ¹*Korea Photonics Technology Inst., South Korea.* We employed multiple number of micro-projectors with HD (1280 by 720) display resolution for light-field technology based-tabletop display systems. Display system is developed for the final target specifications that exhibits 35 inches diagonal with 720p (number of hogels) 3-dimensional image resolution, 5° angular resolution, ±25° viewing angle, and user-display interactive display system

JM4A.8

Advancing Deep Ocean Sensing through Laser Spectroscopy, Anna P. Michel¹, Scott Wankel¹, Jason Kapit¹, Charles Harb², Beckett Colson¹; ¹*WHOI, USA;* ²*Ring-IR, USA.* To advance our understanding of ocean chemistry, new in situ sensors are needed. By coupling gas extraction techniques to laser-based sensors, we can measure key gases such as methane and carbon dioxide in ocean environments.

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JM3E • Not Your Dentist's X-ray (COSI/AIO)—Continued

JM3E.5 • 15:45

Computational X-ray Imaging using Document Scanners, Achuta Kadambi¹, Avilash Cramer¹, Richard Lanza¹, Ramesh Raskar¹, Rajiv Gupta^{2,1}; ¹MIT, USA; ²Harvard Medical School, USA. We propose a computational imaging approach enabling document scanners to be used as frugal, high-resolution X-ray imagers. We modify the document scanner optics for X-ray sensitivity and design a post-processing algorithm to denoise images.

DM3F • Incoherent Holography—Continued

DM3F.6 • 15:45

Self-referencing interference incoherent digital holography using geometrical phase lens and linear polarizer, KiHong Choi¹, Sungwon Choi¹, Junkyu Yim¹, Sung-Wook Min¹; ¹Kyung Hee Univ., South Korea. The self-referencing interference incoherent digital holography system is presented. To capture the hologram, the geometrical phase lens is implemented inside the system, functioning as a common-path polarization dependent wavefront splitter and modulator.

3M3G • Measurement I—Continued

3M3G.7 • 15:45

Ultrafast, sensitive, and inexpensive 3 dimensional MMW/THz imaging system using Glow Discharge Detector Array and CCD camera based on upconversion to visual band, Amir Abramovich¹, Daniel Rozban¹, Avihai Aharon¹, Yitzhak Yitzhaky², Natan Kopeika²; ¹Ariel Univ., Israel; ²Ben Gurion Univ., Israel. A 3 dimensional MMW/THz imaging system using the upconversion mechanism of glow discharge detectors is demonstrated. The MMW/THz radiation is converted to the visual band using an inexpensive glow discharge detector array and basic optical CCD camera to yield the MMW/THz image.

SM3H • Sensing I—Continued

SM3H.5 • 15:45

Fast and Calibration-Free Trace-Gas Monitoring Based On Beat Frequency Quartz-Enhanced Photoacoustic Spectroscopy, Hongpeng Wu¹, Lei Dong¹, Huadan Zheng¹, Xukun Yin¹, Suotang Jia¹, Frank Tittel²; ¹Shanxi Univ., China; ²Rice Univ., USA. Beat frequency QEPAS sensor for ultra-sensitive calibration-free trace gas detection was developed. The resonance frequency and Q-factor of the quartz tuning fork as well as the trace gas concentration can be obtained simultaneously.

16:00–17:00 Coffee Break with Exhibitors, Palms Foyer

Salon FGH1

16:00–17:00
JM4A • Poster Session I

JM4A.9

Ultrasonic-Assisted Blood Glucose Monitoring using Mid-Infrared Spectroscopy, Hiroyuki Nomura¹, Keita Mori¹, Natsumi Kawashima¹, Tomoya Kitazaki¹, Akira Nishiyama¹, Kenji Wada¹, Ichiro Ishimaru¹; ¹Kagawa Univ., Japan. We propose to monitor blood glucose concentrations using mid-infrared spectroscopy in an ultrasonic-assisted liquid cell that can be attached to a dialyzer. This method can measure the transmitted light through whole blood during dialysis.

JM4A.10

Bandwidth Dependent Blurring Reduction Technique in Holographic Display, Mehdi Askari¹, Jae-Hyeung Park¹; ¹Inha Univ., South Korea. In this paper, we propose a method to deal with the image blurring problem that arises due to the use of an extended linewidth light source in holographic displays. Our proposed method pre-compensates the target image with the point spread function of the optical system calculated for the finite linewidth of the source.

JM4A.11

Solving the Transport-of-Intensity Equation without the Usual Intensity Restrictions, Soheil Mehrabkhani¹, Lennart Wefelnberg¹, Thomas Schneider¹; ¹Technische Universität Braunschweig, Germany. Solving the Transport-of-intensity equation (TIE) by a Fourier-Transform (FT) requires some assumptions related to the intensity distribution. In this paper, we present an iterative approach, which removes all these restrictions and provides very accurate results.

JM4A.12

Higher harmonic detection and sensitivity to drifts in trace-gas sensors— Novel schemes for precision measurements, Mohammad A. Khan¹, Caio Azavedo¹, Joseph Jefferey¹, May Hliang¹; ¹Delaware State Univ., USA. We show the advantages of wavelength modulation spectroscopy for improving sensitivity in trace-gas detection. This is achieved using higher harmonic detection to probe spectral features of the absorption signal around linecenter and in line-wing region.

JM4A.13

Real-Time Gaze Optimization of Multi-Layer Stereoscopes Using GPU Parallel Computing, Youngjin Jo¹, Seungjae Lee¹, Jaebum Cho¹, Byoungho. Lee¹; ¹Seoul National Univ., South Korea. We present a real-time optimization method using GPU parallel processing for the image misalignment problems caused by the pupil swim in multi-layer stereoscopes. The simulation results show that this resolves the misalignment of the image and enables real-time operation.

JM4A.14

A large-angle solar concentrator using volume holograms, Yao Cui¹, Jianshe Ma², Ping Su², Tianfeng WU¹; ¹Dept. of Precision Instrument, Tsinghua Univ., China; ²Graduate School at Shenzhen, Tsinghua Univ., China. We design a large-angle (16°) solar concentrator using three cascaded volume holographic elements (two gratings and one lens). By overlapping the working angle-range of each element, we get relatively stable light intensity on the solar cell.

JM4A.15

Compensation of reconstructed depth distortion caused by optical misalignment on holographic projection system, Hayan Kim¹, Keehoon Hong¹, Minsik Park¹, Jinwoong Kim¹; ¹ETRI, South Korea. We propose a numerical compensation method for reconstructed depth distortions caused by inaccurate optical alignment on a holographic projection system. The feasibility of the proposed compensation method is verified by experiments.

JM4A.16

Sub-surface Thermal Imaging of Microelectronic Devices using Confocal Laser Scanning Thermoreflectance Microscopy, Dong Uk Kim¹, Chan Bae Jeong¹, Jung Dae Kim¹, Ki Soo Chang¹; ¹Korea Basic Science Inst., South Korea. We report on a confocal thermoreflectance imaging system, which provides the elimination of out-of-focus reflections, and demonstrate the improvement of ~23 times in the sensitivity due to the confocality during the sub-surface thermoreflectance measurement.

Salon FGH1

16:00–17:00
JM4A • Poster Session I

JM4A.17

An Experimental and Theoretical Investigation of CO-QEPAS Sensor Based on a High Power DFB Diode Laser, Yao Tong¹, Yufei Ma¹, Ying He¹, Xin Yu¹; ¹Harbin Inst. of Technology, China. A high sensitive CO-QEPAS sensor with a high power 2.33 μm diode laser was demonstrated. A 11.2 ppm detection limit was obtained and the pressure and temperature sensitivities of the reported sensor were analyzed.

JM4A.18

Analysis of mean thickness of a phase objects using one-shot phase shifting interferometry, Angel Monzalvo Hernandez¹, German Resendiz-Lopez^{1,3}, Rigoberto Garcia Garcia¹, Juan M. Islas-Islas¹, Luis Garcia Lechuga¹, Jaime Garnica Gonzalez², Victor Flores-Muñoz⁴, Oscar Lira Uribe¹, Noel-Ivan Toto-Arellano¹; ¹Universidad Tecnológica de Tulancingo, Mexico; ²Universidad Autónoma del Estado de Hidalgo, Mexico; ³Instituto de Ciencias Básicas e Ingeniería (ICBI) de la Universidad Autónoma del Estado de Hidalgo, Mexico; ⁴Departamento de Ingeniería Robótica, Universidad Politécnica del Bicentenario, Mexico. In this research a novel interferometric system is reported, which allows the generation of four simultaneous interferograms with phase shifts, the system consists of three coupled interferometers: The optical phase is calculated using the four-step algorithm. The results obtained for static transparent samples are presented.

JM4A.19

Withdrawn

JM4A.20

On the Rotation Angle of Reconstruction Plane in Optical Phase-only Image Encryption and Multiplexing, Hsuan-Ting Chang¹, Yao-Ting Wang¹, Yu-Hsuan Chou¹; ¹National Yunlin Univ. of Science and Tech, Taiwan. We investigate the effects on rotation angle arrangement in the proposed angle multiplexing method for optical image encryption using the phase-only function in the Fresnel transform domain. The computer simulation results show that the images reconstructed with the asymmetric rotation angles can be more secure than that with symmetric arrangements.

JM4A.21

Holographic 3D particle tracking based on numerical diffraction propagation and correlation recognition, Zhe Wang^{1,2}, Biagio Mandracchia², Vittorio Bianco², Pascale Memmolo², Zhuqing Jiang¹, Pietro Ferraro²; ¹College of Applied Sciences, Beijing Univ. of Technology, China; ²CNR-ISASI, Italy. A holographic 3D particle tracking method based on numerical diffraction propagation and correlation recognition is applied on film drainage analysis and red blood cells counting. Location of particles in different depth layers are revealed accurately.

JM4A.22

Special non-diffracting beams analysis by digital holography, Marcos R. Gesualdi¹, Indira S. V. Yepes¹, Rafael A. B. Suarez¹, Santiago R. C. Fernandez¹; ¹Universidade Federal do ABC, Brazil. In this work, we present the experimental realizations of phase and intensity analysis of the non-diffracting beams (Bessel, Mathieu and superposition of co-propagating Bessel beams - Frozen Waves) are made through computer-generated holograms reproduced in spatial light modulators and digital holography. The results are in agreement with the theoretical predictions and are presenting excellent prospects for the beam type analysis with potential applications in optical micromanipulation and optics communications.

JM4A.23

Using digital Zernike phase-contrast for the focus-plane detection of pure phase objects analyzed with DHM., Maria L. Cruz¹; ¹Facultad de Ingeniería, Universidad Panamericana, Mexico. We propose to use digital Zernike phase-contrast and two criteria to find the focus plane of pure phase objects. We present the simulation results of the method where the focus is well detected.

JM4A.24

Thickness and refractive index analysis of ellipsometry data of ultra-thin semi-transparent films, Poul-Erik Hansen^{2,1}, Jonas S. Madsen^{2,1}; ¹Danish national metrology Inst. (DFM), Denmark; ²Nanometrology, Danish Fundamental Metrology, Denmark. Ellipsometry measurement of both the refractive index and the thickness of ultra-thin semi-transparent film are a great challenge in optical metrology today. Here we present a new method making this possible.

JM4A.25

Thin-film drainage study based on holographic 3D particle tracking, Zhe Wang^{1,2}, Biagio Mandracchia², Vincenzo Ferraro³, Ernesto Di Maio³, Pier Luca Maffettone³, Zhuqing Jiang¹, Pietro Ferraro²; ¹College of Applied Sciences, Beijing Univ. of Technology, China; ²CNR-ISASI, Italy; ³Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Università di Napoli Federico II, Italy. Thin-film drainage process has been studied by a digital holographic recording system. In this study, trajectories of three particles inside a bubble film are revealed by holographic 3D tracking during the bubble growth.

JM4A.26

Towards sub-mm-size Helmholtz Photoacoustic Cells for Atmospheric Gas Sensing: simulation and developments, Virginie Zeninari¹, Chehem Mohamed Ibrahim¹, Raphael Vallon¹, Bertrand Parvite¹; ¹Universite de Reims Champagne-Ardenne, France. In the framework of research program called MIRIAD, GSMA reports simulations and developments of mm-size Helmholtz resonant photoacoustic cells for the optical sensing of the atmosphere when associated with mid-infrared sources such as QCLs.

JM4A.27

Statistical Analysis of 3D Digital Holographic Images of Phase-Inhomogeneous Objects, Igor Panko¹; ¹Chernivtsi National Univ., Ukraine. A new principle for recording information on the structure of optically inhomogeneous layers is proposed. Principles of variations of the polarization state of illuminating laser radiation using a reference wave are used. A digital holographic algorithm for obtaining three-dimensional Muller-matrix images of phase-inhomogeneous layers is presented. The statistical moments of the first and fourth orders are determined, which characterize the layered anisotropy of biological layers.

JM4A.28

Development of bifocal holographic lens using a photopolymer, Hui-Ying Wu¹, Chang-Won Shin¹, Sang-Keun Gil², Nam Kim¹; ¹Chungbuk National Univ., South Korea; ²Suwon Univ., South Korea. A bifocal holographic lens using a photopolymer is presented in this paper. We used monochromatic light to evaluate the holographic optical element (HOE) by measuring the diffraction efficiencies of holographic gratings. The experimental results confirm that the bifocal holographic lens can focus on two different points.

JM4A.29

Withdrawn

JM4A.30

Noise Reduction for Projection of Cone Beam Computed Tomography Based on Prior Knowledge, Fuqiang Yang¹, Dinghua Zhang¹, Kuidong Huang¹, Yafei Yang¹; ¹NWPU, China. The study aims to investigate a new algorithm applying to the projection to generate high quality images by reducing the noise in cone-beam computed tomography (CBCT). A single sampling without object is first employed in scanning to obtain the noise as the knowledge, then a random Gaussian Matrix (GM) is used to get a new noise map. Study results demonstrated significant improvement in SNRs of the images by overlapping the noise map on the projection for average. Since the noise is reduced, it has the potential to improve projection quality.

JM4A.31

Fresnel Holograms Generation Using Partitioned Holograms and Fast Cosine Transform, Fabriciu A. Benini¹, Ben-Hur V. Borges¹, Luiz G. Neto¹; ¹Universidade de Sao Paulo, Brazil. We suggest the use of partitioned holograms to decrease the time calculation of Fresnel holograms. We show that the time calculation can be decreased about 3 times partitioning the desired Fresnel hologram into 16 or more sub holograms.

JM4A.32

A phase-space approach to optical resolution, Cagatay Isil¹, Figen S. Oktem¹; ¹Middle East Technical Univ., Turkey. We show, using a phase-space approach, how to determine the diffraction-limited resolution for imaging systems with multiple diffracting apertures. A microscope objective is analyzed using the developed approach, and results are compared with the known technical specifications.

JM4A.33

Multiplexing Multiple Digital Holograms for Efficient Transmission and Recovery, Ravi Shekhar², Gopinathan Unnikrishnan², Naveen K. Nishchal¹; ¹Indian Inst. of Technology Patna, India; ²Applied Physics, Defence Inst. of Advanced Technology, India. For efficient transmission of multiple digital holograms simultaneously, we multiplex them into a single package. An encoding mechanism and orthogonal random binary masks are employed to recover better quality and cross-talk free images.

JM4A.34

Accommodometer for Light Field display, Kwang-Hoon Lee¹; ¹*Korea Photonics Technology Inst., South Korea*. We had study that verifying whether the LF display provides accommodative function, and quantifying the focusable range at the reconstruction image space in which permitted by the focusable power served by the display

JM4A.35

Surface roughness sensing with singular vortex beams, Bohdan V. Sokolenko¹; ¹*V.I. Vernadsky Crimean Federal Univ, Russia*. In the present research we discuss the results of analysis of coherent light beams carrying optical vortex. Vertical resolution of vortex roughness probing can be achieved down to 5,27 nm for He-Ne laser source.

JM4A.36

Parallel phase-shifting interferometer with four interferograms using a modified Michelson configuration, Luis Garcia Lechuga¹, Gustavo Rodriguez Zurita³, David Serrano Garcia², German Resendiz-Lopez^{1,5}, Angel Monzalvo Hernandez¹, Rigoberto Garcia Garcia¹, Jaime Garnica Gonzalez⁴, Salvador Hernandez Mendoza¹, Juan M. Islas-Islas¹, Noel-Ivan Toto-Arellano¹; ¹*Universidad Tecnológica de Tulancingo, Mexico*; ²*Centro Universitario de Ciencias Exactas e Ingenierías, Universidad de Guadalajara, Mexico*; ³*Benemerita Universidad Autónoma de Puebla, Mexico*; ⁴*Instituto de Ciencias Básicas e Ingeniería, Universidad Autónoma del Estado de Hidalgo, Mexico*; ⁵*Doctorado en Ciencias en Ingeniería Industrial, Instituto de Ciencias Básicas e Ingeniería (ICBI), Universidad Autónoma del Estado de Hidalgo, Mexico*. In this paper, we report an optical implementation of a parallel-phase-shifting-interferometer that uses two Michelson interferometers for generate two-interferograms, to present the capabilities of the system, phase measurements results obtained from transparent structures are presented.

JM4A.37

Relevance analysis for texture descriptors in studies of dynamic photoelasticity, Hermes Fandiño^{1,2}, Juan C. Briñez de León¹, Alejandro Restrepo Martínez¹, John W. Branch Bedoya¹; ¹*Universidad Nacional de Colombia, Colombia*; ²*ITM, Colombia*. Analyzing fringe patterns in photoelasticity images is a common process for describing stress concentration zones. Notwithstanding, we show that an unique texture descriptor could be insufficient for describing the ROI texture in dynamic photoelasticity.

JM4A.38

Withdrawn

JM4A.39

Nonlinear optical single-molecular image technique and its applications, Xiaoming Wang¹; ¹*Hubei Univ. of Chinese Medicine, China*. Nonlinear optical single-molecular image technique is our patented new optical microscopy technique(Chinese patent 200910060951.7, PCT /CN2010/000138). It has broad applications in many areas. In the paper, we presented the principle of single molecular profile image magnifying technique and its lot of application.

JM4A.40

Experimental demonstration of superresolution using signum phase mask, Bohumil Stoklasa¹, Martin Paur¹, Jaroslav Rehacek¹, Zdenek Hradil¹, Jai Grover², Andrej Krzic², Luis L. Sanchez-Soto^{3,4}; ¹*Univerzita Palackeho v Olomouci, Czechia*; ²*ESA-ESTEC, Netherlands*; ³*Universidad Complutense, Spain*; ⁴*Max-Planck Inst., Germany*. We experimentally show, how an imaging system incorporating phase signum mask can improve the resolution of two incoherent points. Mean squared error of two points separation estimator for standard and modified detection is discussed.

JM4A.41

HBT Telescope based on self-Correlation in Spatial Domain, Zhentao Liu^{1,2}, Xia Shen^{1,2}, Jianrong Wu^{1,2}, Enrong Li^{1,2}; ¹*SIOM, CAS, China*; ²*Univ. of Chinese Academy of Sciences, China*. HBT telescope based on self-correlation in spatial domain can realize lensless imaging in a single measurement, which overcomes the measurement limitations of HBT interferometry. The simulation and discussion verify its correctness and feasibility.

JM4A.42

Detecting the Presence of a Transparent Object in Off-axis Digital Holograms, Tomi Pitkaaho¹, Aki Manninen², Thomas J. Naughton¹; ¹*Maynooth Univ., Ireland*; ²*Biocenter Oulu, Univ. of Oulu, Finland*. Detecting presence of an object in digital holograms is an important consideration in many applications. We propose a novel method that works directly in the hologram plane to determine the presence or absence of an object.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security
and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

17:00–18:30

AM5A • Look to the Stars

Presider: Ivan Capraro; *Adaptica Srl, Italy*

AM5A.1 • 17:00 Invited

Fast Aberration Correction with Multi-Actuator Adaptive Lenses in Medium Size Telescopes and Complex Laser Systems, Stefano Bonora¹; ¹CNR-IN-FM, Italy. Fast adaptive optics systems with deformable mirrors have been used to correct for time variant aberrations induced by air turbulence. We will show that the multi actuator adaptive lenses can replace deformable mirrors in such applications with the advantage of a simpler and more compact optical setup. We will show the results obtained on medium size telescopes and to improve the stability of complex laser systems.

DEMO

The demonstrative system that includes a Multi actuator Adaptive Lens in closed loop control with a Shack Hartmann wavefront sensor working at 400Hz. We will show wavefront correction and far field beam shaping with the adaptive lens.

17:00–18:30

IM5B • Biomedical II

Presider: Maitreyee Roy; *Univ. of New South Wales, Australia*

IM5B.1 • 17:00 Invited

Angiography, Lymphangiography, Elastography and Polarisation Contrast Extensions of Optical Coherence Tomography, David D. Sampson^{2,1}; ¹Univ. of Western Australia, Australia; ²Univ. of Surrey, UK. Optical coherence tomography is being extended beyond native scattering contrast to probe features of biological tissues, such as motion to detect vessels, stress response to detect stiffness, and polarized light response to detect sub-wavelength-resolution structural order. Many applications of tissue characterization will be presented.

IM5B.2 • 17:30 Invited

Integrated Tissue Analytics for Clinical Imaging Systems, Dmitry V. Dyllov¹; ¹Skolkovo Inst. of Science and Technology, Russia. We will overview some recent advancements in the in-situ evaluation of tissues using imaging systems that rely on optical spectroscopy, fluorescence imaging, and multiplexed microscopy. Computational and analytical methods of real-time tissue differentiation will be considered.

17:00–18:30

LM5C • Atmospheric & Environmental Monitoring I

Presider: Virginie Zeninari; *Universite de Reims Champagne-Ardenne, France*

LM5C.1 • 17:00 Invited

Multi-Parameter IC Engine Exhaust Gas Diagnostics - From Manifold, Via Aftertreatment to the Tail Pipe End, Steven Wagner¹, Luigi Biondo¹, Niels Göran Blume¹, Oliver Diemel¹, Johannes Emmert¹, Lisa Engel¹, Anna K. Schmidt¹, Felix Stritzke¹; ¹High Temperature Process Diagnostics, Inst. of Reactive Flows and Diagnostics, Technische Universität Darmstadt, Germany. More stringent exhaust emissions regulation of IC engines requires more detailed investigation of the after treatment and conversion processes of the exhaust flow. Here, we present three independent laser absorption spectrometers for the measurement of mole fractions and temperature during EGR, SCR after treatment and at the tail pipe end.

LM5C.2 • 17:30

Gas Mixtures Characterization Using a Field Programmable Gate Array (FPGA): CO₂/O₂ Case Study, Herve Tatenguem Fankem¹, Tobias Milde¹, Morten Hoppe¹, Andreas Sacher¹, Joachim Sacher¹; ¹Sacher Lasertechnik GmbH, Germany. We report on the development and validation of an FPGA-based algorithm, for studying and characterizing gas mixtures. The proposed algorithm is successfully used to analyze a mixture of CO₂/O₂ in different proportions.

17:00–18:30

MM5D • Inverse Scattering

Presider: Josselin Garnier; *Ecole Polytechnique, France*

MM5D.1 • 17:00 Invited

Inverse Problems in Acoustic-Optic Imaging, John C. Schotland¹; ¹Univ. of Michigan, USA. Abstract to be determined.

MM5D.2 • 17:30

Imaging Through Volumetric Scattering with a Single Photon Sensitive Camera, Guy Satat¹, Matthew Tancik¹, Ramesh Raskar¹; ¹MIT Media Lab, USA. Imaging through highly scattering media holds many opportunities in underwater and biomedical imaging. Here we leverage a single photon avalanche diode (SPAD) camera, and experimentally demonstrate an imaging pipeline to see through turbid water in optical reflection mode.

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

17:00–18:15

CM5E • Depth-Resolved and Turbid Imaging

President: Rajesh Menon; Univ. of Utah, USA

CM5E.1 • 17:00

Multi-layered Born Scattering Model for 3D Phase Imaging with Multiple Scattering Objects, Michael Chen¹, Hsiou-Yuan Liu¹, David Ren¹, Laura Waller¹; ¹UC Berkeley, USA. We demonstrate a 3D phase imaging model for scattering objects with intensity-only measurements taken with patterned illumination in an LED array microscope. 3D refractive index (RI) of polystyrene beads is recovered, and the preliminary results indicate that the proposed model outperforms existing methods in terms of quantitative accuracy of RI.

CM5E.2 • 17:15

Depth-resolved Lensless Imaging, Mengqi Du¹, Kjeld Eikema¹, Stefan Witte¹; ¹ARCNL, Netherlands. A numerical approach is developed to reconstruct 3D images from a set of wavelength- and phase-resolved diffraction patterns, resulting in a computational depth-resolved imaging method.

CM5E.3 • 17:30

3D Fluorescence Microscopy with DiffuserCam, Grace Kuo¹, Nick Antipa¹, Ren Ng¹, Laura Waller¹; ¹Univ. of California Berkeley, USA. We propose a lensless diffuser-based microscope for 3D fluorescence microscopy from a single exposure. We use compressed sensing and a local convolution model to account for the system's spatially-varying point spread functions in a computationally efficient manner.

17:00–18:15

DM5F • Applications of DH

President: Peter Schelkens; Vrije Universiteit Brussel, Belgium

DM5F.1 • 17:00 **Invited**

Interferometric out-of-focus imaging of ice particles for airborne instrumentation, Marc Brunel¹, Mohamed Talbi¹, Sébastien Coëtmelec¹, Denis Lebun¹, Gérard Gréhan¹, Michael Fromager², Kamel Aït Ameur², Yingchun Wu³, Justin Jacquot-Kielar⁴; ¹CNRS UMR 6614 CORIA, France; ²ENSICAEN, France; ³Zhejiang Univ., China; ⁴Mc Gill Univ., Canada. The set of experimental and numerical tools that have been developed to perform interferometric out-of-focus images of ice particles is presented. The different experimental results that have been obtained and that validate the measurement method are presented, analyzed and discussed.

DM5F.2 • 17:30

Vibration retrieval from time sequences of digital on-line Fresnel holograms, Laure Lagny¹, Carlos Alejandro Trujillo Anaya², Julien Le Meur³, Silvio Montessoro¹, Jorge Garcia-Sucerquia², Kevin Heggarty³, Charles Pezerat¹, Pascal Picart¹; ¹LAUM CNRS Université du Maine, France; ²Universidad Nacional de Colombia-Sede Medellín, Colombia; ³Telecom Bretagne, France. This paper proposes an on-line holographic configuration for full-field vibration retrieval at 100kHz. Negative zoom and DOE are combined to yield the best photometric efficiency. Experimental results demonstrate the suitability of the proposed approach.

17:00–18:30

3M5G • HMD & Aerial Display

President: Bahram Javidi; Univ. of Connecticut, USA

3M5G.1 • 17:00 **Invited**

Fundamental Limitations for Augmented Reality Displays with Visors, Waveguides, or Other Passive Optics, Barmak Heshmat^{1,2}; ¹Meta Company, USA; ²Media Lab, MIT, USA. This study identifies fundamental limitations and trade-offs enforced by laws of optics for any augmented reality display that uses passive optical elements such as visors, waveguides, and meta-surfaces to deliver the image to the eye.

3M5G.2 • 17:30 **Invited**

How Recent Optical Technology Breakthroughs Enable Next Generation Head Mounted Displays, Bernard Kress¹; ¹Microsoft Corp, USA. Virtually all HMDs currently available on the market, in either VR, AR or MR form, lack both wearable and visual comfort, two major experience pillars required to enable the analyst's impressive digital reality markets. Conventional optical designs limit today cruelly all HMD architectures. However, recent optical breakthroughs might provide alternate architectures to counter such dire hardware limitations.

17:00–18:30

SM5H • Sensing II

President: David Rabb; US Air Force Research Lab, USA

SM5H.1 • 17:00 **Invited**

A Bayesian Framework for Imaging and Atmospheric Sensing using Coherent Laser Radar, Charles A. Bouman¹; ¹Purdue Univ., USA. Optically-coherent imaging systems offer significant improvements in sensitivity, resolution, and atmospheric turbulence sensing and mitigation compared to non-coherent systems. Conventional approaches for processing optically-coherent data are based on relatively-simple inversion techniques which produce speckled images and poor turbulence estimates.

SM5H.2 • 17:30

Application of the correlation transport equation to photon Doppler velocimetry of ejecta from shock-loaded samples, Arseniy N. Kondratyev¹; ¹Dukhov Research Inst. of Automatics, Russia. The report addresses the actual problem of photon Doppler velocimetry of ejecta from shock-loaded metal samples. It is shown that, for modeling the Doppler spectrum from an expanding cloud of ejected particles, the correlation transport equation can be applied.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security
and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

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AM5A • Look to the Stars—Continued

AM5A.2 • 17:45 **Invited**

Quantum Communication in Space - Challenges and Opportunities, Imran Khan^{1,2}; ¹*Division Leuchs - Quantum Information Processing Group, Max Planck Inst. for the Science of Light, Germany*; ²*InfiniQuant, Germany*. In this talk we present the challenges and opportunities associated with bringing economically feasible quantum key distribution to space, which is currently the only viable alternative to bridge global distances for quantum communication.

DEMO

We show a proof-of-principle experiment on quantum random number generation. The experiment is based on homodyne (coherent) detection of the quantum vacuum state of light. This can be done using off-the-shelf telecom components.

IM5B • Biomedical II—Continued

LM5C • Atmospheric & Environmental
Monitoring I—Continued

LM5C.3 • 17:45

Fast and Widely-tunable, VBG Spectrally Narrowed, Picosecond Optical Parametric Oscillator for Backscatter Absorption Gas Imaging, Guillaume Walter¹, Jean-Baptiste Dherbecourt¹, Jean-Michel Melkonian¹, Myriam Raybaut¹, Antoine Godard¹, Didier Henry¹, Cyril Drag²; ¹*Onera, The French Aerospace Lab, France*; ²*Laboratoire de Physique des Plasma, Ecole Polytechnique-CNRS-Univ Paris-Sud-UPMC, Université Paris-Saclay, France*. We implement a fast and widely tunable picosecond OPO, based on an aperiodically-poled nonlinear crystal, tuned and spectrally narrowed by a chirped VBG, for backscatter absorption gas imaging of N₂O around 3.82 μ m.

LM5C.4 • 18:00

Development of broadband cavity enhanced spectroscopy and its application in trace gases, peroxy radicals and aerosol optical detection, Weixiong Zhao¹, Xuezhe Xu¹, Bo Fang¹, Yang Zhang¹, Weijun Zhang¹, Weidong Chen²; ¹*AIOFM, CAS, China*; ²*LPCA, ULCO, France*. We report the development of broadband cavity enhanced spectroscopy for trace gases, its combination with chemical amplification for peroxy radicals measurement, and with integrating sphere for simultaneous in situ measurements of aerosol scattering and extinction.

LM5C.5 • 18:15

Detectorless Intracavity Technique with an EC-QCL for Atmospheric Gas Detection, Raphael Vallon¹, Laurent Bizet¹, Bertrand Parvitte¹, Gregory Maisons², Mathieu Carras², Virginie Zeninari¹; ¹*Université de Reims Champagne-Ardenne, France*; ²*MirSense, France*. We report the development of an external-cavity quantum cascade laser emitting in the mid-infrared region and its application to the detectorless intracavity detection of atmospheric molecules such as methane and water vapor.

MM5D • Inverse Scattering—Continued

MM5D.3 • 17:45

Optimizing Defect Detectability across Multiple Ultraviolet Wavelengths, Mark-Alexander Henn¹, Bryan M. Barnes¹, Hui Zhou¹, Richard M. Silver¹; ¹*NIST, USA*. We investigate defect detectability using simulated deep-, vacuum-, and extremeultraviolet wavelengths. Improvements to a signal-to-noise ratio defect metric appear achievable down to $\lambda = 47$ nm.

MM5D.4 • 18:00 **Invited**

Computational 4D imaging in widefield microscopy with partially coherent illumination, Jose A. Rodrigo¹, Juan M. Soto¹, Tatiana Alieva¹; ¹*Complutense Univ. of Madrid, Spain*. We present a system and computational technique exploiting the advantages of partially coherent illumination paving the way for 4D label-free imaging in conventional widefield microscopy. The experimental demonstrations include video-rate speckle-noise-free 3D imaging of biological cells.

18:30–20:00 Congress Reception, Palms Ballroom E

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

CM5E • Depth-Resolved and Turbid
Imaging—Continued

CM5E.4 • 17:45

Double-Cubic Point Spread Function for 3D Extended-Depth Localization Microscopy, Yongzhuang Zhou¹, Vytautas Zickus¹, Andrew R. Harvey¹, Paul Zammit¹; ¹Univ. of Glasgow, UK. We report the design and implementation of a new pupil-engineered phase function that enables simple and robust 3D localization microscopy with a ten-fold extension in depth-of-field. Applications include single-particle tracking, super resolution microscopy and lab-on-chip. We demonstrate its application to in-vivo mapping of blood flow in zebrafish.

CM5E.5 • 18:00

Depth Sensitivity Improvement of Region-of-Interest Diffuse Optical Tomography from Superficial Signal Regression, Manob Jyoti Saikia^{1,2}, Rakesh Manjappa¹, Kunal Mankodiya², Rajan Kanhirodan¹; ¹Physics, Indian Inst. of Science, India; ²Electrical, Computer and Biomedical Engineering, Univ. of Rhode Island, USA. We report depth sensitivity enhancement of a region-of-interest optical tomographic system. Two optode configurations, 25 and 50 mm separations are used to construct a noise model. A regression technique isolates the functional activity of deep tissue layer.

DM5F • Applications of DH—Continued

DM5F.3 • 17:45

Digital Holographic Interferometry Application On Objects With Heterogeneous Reflecting Properties, Jean-François Vandenrijt¹, Yuchen Zhao¹, Fabian Languy¹, Cédric Thizy¹, Marc P. Georges¹; ¹Centre Spatial de Liège - STAR Research Unit, Liège Université, Belgium. Some objects of industrial interest show zones which can be either scattering or specular. We present experimental digital holographic interferometry results obtained in a setup dealing with both at the same time.

DM5F.4 • 18:00

Ultrahigh-throughput rendering of digital holograms, Michael Atlan¹; ¹CNRS, France. The advent of commodity computer graphics processing units has made video-rate and ultrafast holographic image rendering possible by streamline processing of optically-acquired interferograms. We present holovibes, a software designed to perform sustained ultrahigh-throughput digital hologram rendering with real-time visualization.

3M5G • HMD & Aerial Display—Continued

3M5G.3 • 18:00

Curved screen virtual reality headsets, Ginni Grover¹, Basel Salahieh¹, Oscar Nestares¹; ¹Intel Corporation, USA. With the flexible displays on market horizon, we can now design VR systems with an additional degree of freedom. We show curved screen designs can improve the field of view or optical resolution in VR.

3M5G.4 • 18:15

Forming Underwater Information Display with Aerial Imaging by Retro-Reflection (AIRR), Hirotsugu Yamamoto^{1,2}, Kenta Onuki¹, Sho Onose¹; ¹Utsunomiya Univ., Japan; ²ACCEL, JST, Japan. This paper proposes a new technique to form a real image in the water. The underwater image is formed by use of a retro-reflector. We have succeeded in forming an underwater information display.

SM5H • Sensing II—Continued

SM5H.3 • 17:45 **Tutorial**

Experiences as an Expert Witness in the Uber vs Google/Waymo Lidar for Driverless Car Case, Paul McManamon¹; ¹Exciting Technology LLC, USA. Paul McManamon will discuss his experiences as an expert witness in Uber vs Google/Waymo Lidar for Driverless Car trial. This was a very high profile case, and McManamon's first experience as an expert witness.

18:30–20:00 Congress Reception, Palms Ballroom E

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:30 Registration, Palms Foyer

Citron

08:00–09:00

JTU1A • Plenary Session II with OSA Light the Future Speakers Series

JTU1A.1 • 08:00 **Plenary**

The Role of Optics and Photonics in the Vehicles of Tomorrow, Jason Eichenholz, *Luminar Technologies, USA*. This presentation will take a high level look at the future of optics and photonics technologies in autonomous vehicles. Optics are a crucial component in an industry headed for extreme disruption over the next few decades and will play a critical role in shaping the future of navigation, passenger experience and the ultimate safety of the autonomous trip. The key components of all-things-optic, including LiDAR, laser headlights, passenger monitoring and interior lighting and displays, the role each plays inside a future automobile and its impact on the transportation industry will be discussed.

09:00–10:00 Coffee Break with Exhibitors, Palms Foyer

10:00–12:00

ATu2A • Keynote and Laser Sorcery

Presider: Joseph Dallas; Avo Photonics Inc, USA

10:00–11:45

ITu2B • Microscopy I: Super-resolution & Illumination Techniques

Presider: Kristina Irsch; Johns Hopkins University, USA

10:00–12:00

LTu2C • Combustion Diagnostics I

Presider: Daniel Richardson; Sandia National Labs, USA

10:00–12:00

MTu2D • High-Dimensional Imaging

Presider: Laure Blanc-Féraud; CNRS, USA

10:00–12:00

CTu2E • Compressive Sensing 1

Presider: Jun Ke; Beijing Inst. of Technology, China

ATu2A.1 • 10:00 **Keynote**

Risks of Comfort Zone, and Benefits of Leaving it: An Entrepreneurial Roller Coaster Story, E Hooman Banaei, *Everix Optical Filters, USA*. Banaei will share the ups and downs of his entrepreneurial journey of starting in a garage and moving towards making a photonic component a new household name by touching lives of potentially billions.

ITu2B.1 • 10:00 **Invited**

Super-resolution confocal microscopy using optical nonlinearity, Katsumasa Fujita¹; ¹Osaka Univ., Japan. Utilizing the nonlinear optical effect is key to break the diffraction limit. I present the techniques to induce the higher-order nonlinearity in light excitation and scattering that improve the spatial resolution in confocal microscopy.

LTu2C.1 • 10:00 **Invited**

1D single-shot thermography by Spontaneous Raman Scattering in turbulent, spray or oxyfuel flames, Armelle Cessou^{1,2}, Florestan Guichard¹, hassan Ajrouche¹, Amath Lo¹; ¹Université de Rouen, France; ²CNRS, France. Spontaneous Raman scattering noise, limited for thermography in turbulent flames where high spatial and time resolutions are required, is revisited for simultaneous temperature and multispecies concentration single-shot linewise measurements, offering new applications.

MTu2D.1 • 10:00 **Invited**

Accidental Cameras: using naturally occurring apertures and occluders to form images, Bill Freeman¹; ¹MIT, USA. We study cameras that are accidentally formed in scenes, from pinhole, pinspeck, and single-edge occluders that we call “corner cameras”. These cameras can reveal details about a scene that are otherwise invisible.

CTu2E.1 • 10:00 **Invited**

Single-shot 10 THz Compressed Ultrafast Photography, Lihong V. Wang¹, Jinyang Liang¹, Liren Zhu¹; ¹California Inst. of Technology, USA. We have developed single-shot 10-trillion-frame-per-second compressed ultrafast photography (T-CUP), which can passively capture dynamic events with 100-fs frame intervals in a single camera exposure. This upgrade is 100 times faster than our original version.

ITu2B.2 • 10:30

Improved Lateral Resolution of Continuous Wave STED Microscopy using Standing Wave in focus, Geon Lim¹, Wan-Chin Kim², Han-wook Yi¹, No-Cheol Park¹; ¹Yonsei Univ., South Korea; ²Honam Univ., South Korea. To improve lateral resolution of CW STED microscopy, interference generated standing wave by apodization aperture in excitation beam is introduced. Theoretical calculation and experiments are fulfilled, and the results show enhanced resolution than conventional case.

LTu2C.2 • 10:30

Backward lasing for range-resolved detection of atomic hydrogen in a methane-oxygen flame, Maria Ruchkina¹, Pengji Ding¹, Andreas Ehn¹, Marcus Aldén¹, Joakim Bood¹; ¹Lund Univ., Sweden. We demonstrate range-resolved detection of atomic hydrogen in methane/oxygen flames based on 2-photon excited backward lasing using 205-nm femtosecond laser pulses. Range resolution is achieved by temporally resolving the backward emission with a streak camera.

MTu2D.2 • 10:30

Surface Estimation of Small Animals from Orbital Plenoptic Projections, Jörg Peter¹, Mark E. Ladd¹; ¹German Cancer Research Center, Germany. Normalized cross correlation weighted by spatial resolution characteristics of plenoptic cameras is presented, yielding more unique photo-consistency maps from which complex anatomical surfaces can be estimated more accurately at lesser computational cost.

CTu2E.2 • 10:30

Compressive Ultrafast Single Pixel Camera, Guy Satat¹, Gabriella Musarra², Ashley Lyons², Barmak Heshmat¹, Ramesh Raskar¹, Daniele Faccio²; ¹MIT Media Lab, USA; ²School of Physics & Astronomy, Univ. of Glasgow, UK. We experimentally demonstrate a single-pixel, time-resolved camera that, by using the temporal information, produces improved reconstruction quality and shorter acquisition times, compared to traditional, non-time-resolved, single-pixel approaches.

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

Tangerine

Propagation Through and Characterization
of Atmospheric and Oceanic Phenomena

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07:00–18:30 Registration, Palms Foyer

Citron

08:00–09:00

JTu1A • Plenary Session II with OSA Light the Future Speakers Series

JTu1A.1 • 08:00 

The Role of Optics and Photonics in the Vehicles of Tomorrow, Jason Eichenholz, Luminar Technologies, USA. This presentation will take a high level look at the future of optics and photonics technologies in autonomous vehicles. Optics are a crucial component in an industry headed for extreme disruption over the next few decades and will play a critical role in shaping the future of navigation, passenger experience and the ultimate safety of the autonomous trip. The key components of all-things-optic, including LiDAR, laser headlights, passenger monitoring and interior lighting and displays, the role each plays inside a future automobile and its impact on the transportation industry will be discussed.

09:00–10:00 Coffee Break with Exhibitors, Palms Foyer

10:00–11:45

DTu2F • Contemporary Topics in DH

Presider: Marc Georges; Universite de Liege, Belgium

10:00–12:00

3Tu2G • HMD & VAC Solution

Presider: Adrian Stern; Ben Gurion Univ. of the Negev, Israel

10:00–11:45

STu2H • Components I

Presider: Paul McManamon; Exciting Technology LLC, USA

10:00–12:00

PTu2I • Propagation Simulations

Presider: Daniel LeMaster; US Air Force Research Lab, USA

DTu2F.1 • 10:00 

Advances and Challenges in Synthetic Aperture Interferometry, Pablo D. Ruiz¹; ¹Loughborough Univ., UK. Past and recent approaches to SAI will be discussed, focusing on the main challenges towards designing optical systems with a large space-bandwidth product, i.e. large fields of view and high spatial resolution.

3Tu2G.1 • 10:00 

Computational Near-eye Displays: Engineering the Interface between our Visual System and the Digital World, Gordon Wetzstein¹; ¹Stanford Univ., USA. Immersive visual and experiential computing systems, i.e. virtual and augmented reality (VR/AR), are entering the consumer market and have the potential to profoundly impact our society. Applications of these systems range from communication, entertainment, education, collaborative work, simulation and training to telesurgery, phobia treatment, and basic vision research.

STu2H.1 • 10:00 

Reimagine, Whitney Mason; DARPA, USA. Abstract not available.

PTu2I.1 • 10:00 

Physics and Modeling of Optical Waves Propagating Through Atmospheric Turbulence, Ronald L. Phillips¹; ¹CREOL College of Optics and Photonics, Univ. of Central Florida, USA. The turbulence in the atmosphere can strongly affect propagation optical waves. The turbulence is created by a variety of atmospheric conditions. Using a mathematical model the fluctuations of the statistical fluctuations and wave parameters are computed.

DTu2F.2 • 10:30

Compressive holography for imaging behind a diffuser, Liangcai Cao¹, Hua Zhang¹, Wenhui Zhang¹, Hao Zhang¹, Guofan Jin¹; ¹Tsinghua Univ., China. Compressive holography based on sparsity constraint is employed to reconstruct the object behind a weak diffuser. The experimental results demonstrate the effectiveness of the proposed model and the object was extracted from the perturbed hologram.

3Tu2G.2 • 10:30 

Mixed Reality Near-eye Display with Focus Cue, Byoungcho . Lee¹, Changwon Jang¹, Seungjae Lee¹; ¹Seoul National Univ., South Korea. Mixed reality (MR) has received great attention for past few years. Supporting focus cue is regarded as an important factor because it can mitigate the visual fatigue. This paper will overview two main issues in MR technique: realization of see-through displays and supporting focus cue. These two issues are explained with specific experimental setups and results.

STu2H.2 • 10:30 

Opportunities for LIDAR and Free-Space Optical Communications Using Micro-Scale Photonics Technologies, Gordon A. Keeler¹; ¹DARPA, USA. The increasing sophistication and availability of integrated photonics and optical microsystems will enable revolutionary chip-scale solutions for traditionally macroscopic systems. This talk describes DARPA efforts to advance LIDAR and FSO hardware with innovative microsystem technologies.

PTu2I.2 • 10:30

Wave and Ray Optics Simulations of Short Exposure Incoherent Imaging in Atmospheric Turbulence, David Voelz¹, Hanyu Zhan¹, Erandi A. Wijerathna¹; ¹Klipsch School of Electrical and Computer Engineering, New Mexico State Univ., USA. Wave optics and ray tracing simulation results are presented for short exposure incoherent imaging through atmospheric turbulence ranging from weak to strong scintillation regimes. The ray tracing results provide a recognizable approximation to the wave optics results even in the saturation regime, although some loss of high spatial frequency fidelity is apparent.

Sunset/Fleming

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Siesta/Biscayne

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ATu2A • Keynote and Laser Sorcery—Continued

ATu2A.2 • 10:45 **Invited**

Advanced Optical Filters based on a New Generation of Volume Bragg Gratings in Photo-thermo-refractive Glass, Vadim Smirnov¹, Oleksiy Mokhun¹, Leonid Glebov¹; ¹OptiGrate, USA. Nowadays volume Bragg gratings (VBGs) in PTR glass are used in a wide variety of laser systems and applications. In this presentation we discuss VBGs with enhanced parameters developed for spectral sensing and hyper-spectral imaging.

ATu2A.3 • 11:15 **Invited**

Mode Control in T-Cavity Vertical External Cavity surface emitting Lasers (VECSEL), Mahmoud Fallahi^{1,2}, Chris Hennesen^{1,2}; ¹Univ. of Arizona, USA; ²TPhotronics Inc., USA. T-Cavity VECSELs allow for the generation of tunable two-color emission as well as Sum and difference frequency generation. By using intracavity mode control, a range of high power orbital angular momentum beams are demonstrated.

ITu2B • Microscopy I: Super-resolution & Illumination Techniques—Continued

ITu2B.3 • 10:45

Tunable structured illumination system based on a Wollaston prism, Sebastian Bedoya¹, Ana Doblas¹, Genaro Saavedra², Chrysanthos Preza¹; ¹Univ. of Memphis, USA; ²Dept. of Optics, Univ. of Valencia, Spain. Experimental verification of a simple illumination system to generate a 1D structured pattern with tunable modulation frequency is shown based on a Wollaston prism illuminated by the diffracted field of an incoherent linear source.

ITu2B.4 • 11:00

Optimal Path and Illumination Design for Multiframe Motion Deblurring, Sarah Dean¹, Zachary Phillips², Laura Waller^{1,2}, Ben Recht¹; ¹Electrical Engineering and Computer Science, Univ. of California, Berkeley, USA; ²Graduate Group in Applied Science and Technology, Univ. of California, Berkeley, USA. We propose an extension of coded illumination design for motion deblurring to multiframe imaging, where a large field-of-view sample is recovered from many motion-blurred measurements captured while scanning the sample continuously under coded illumination.

ITu2B.5 • 11:15

Speckle-Free Imaging with Nanosecond-Scale Acquisition Using Micro-lens-Stabilized Laser Arrays, Austin W. Steinforth¹, José A. Rivera¹, J. G. Eden¹; ¹Univ of Illinois at Urbana-Champaign, USA. A novel light source comprising as many as 4,000 independent lasers has been developed for speckle-free illumination. Visible-light and near-infrared imaging with exposure time as short as five nanoseconds has been demonstrated.

LTu2C • Combustion Diagnostics I—Continued

LTu2C.3 • 10:45

Quantitative OH Measurements in Turbulent Flames using Laser-Diagnostics with High Spatio-Temporal Resolution, Christoph Arndt¹, Wolfgang Meier¹; ¹German Aerospace Center (DLR), Germany. For time-resolved numerical simulations, quantitative, time-resolved validation data with well-defined boundary conditions are crucial. Here, we present a strategy for quantitative measurements of the OH concentration in turbulent flames and assess the measurement uncertainties.

LTu2C.4 • 11:00

Mid-infrared laser absorption tomography for quantitative temperature, CO, and CO₂ in turbulent flames, Chuyu Wei¹, Daniel I. Pineda¹, Raymond M. Spearrin¹; ¹Dept. of Mechanical and Aerospace Engineering, Univ. of California, Los Angeles, USA. Mid-infrared laser absorption tomography is presented as a quantitative method to spatially-resolve species and temperature profiles in small-diameter flames relevant to practical combustion systems. Example measurements in a canonical turbulent flame are discussed.

LTu2C.5 • 11:15 **Invited**

Non-linear mid-infrared laser techniques for combustion diagnostics, Anna-Lena Sahlberg¹; ¹Lunds Universitet, Sweden. In the past decades, non-linear laser techniques have become an important part of combustion research. The major advantages of non-linear laser techniques are their high temporal and spatial resolution and high sensitivity, the main disadvantages being the more complex setup involved and the more complex data analysis required. Employing non-linear laser techniques in the mid-infrared spectral region has several advantages.

MTu2D • High-Dimensional Imaging—Continued

MTu2D.3 • 10:45

On Scene Reconstruction from Spatial Coherence Measurements, Andre Beckus¹, Alexandru Tamasan¹, Aristide Dogariu¹, Ayman F. Abouraddy¹, George K. Atia¹; ¹Univ. of Central Florida, USA. We determine the positions and dimensions of obscuring and apertures from coherence measurements of partially coherent light by leveraging the authors' recent closed-form approximation formula for the coherence of propagated fields in the Fresnel regime.

MTu2D.4 • 11:00 **Invited**

Learning and Exploiting Physics of Degradations, Paul Escande¹, Valentin Debarnot², Mauro Maggioni¹, Thomas Mangeat³, Pierre Weiss²; ¹Applied Mathematics and Statistics, Johns Hopkins Univ., USA; ²Institut des Technologies Avancées en Science du Vivant, France; ³Lab of Molecular and Cellular Biology of the Proliferation Control, Falkland Islands [Malvinas]. Even though physics of degradations of an acquisition system might be complex, it often relies on a small number of parameters. We present a methodology to learn this physics and exploit it for restoration purposes.

CTu2E • Compressive Sensing 1—Continued

CTu2E.3 • 10:45

Encrypted Single Pixel Imaging with Basis Illumination Patterns, Zibang Zhang², Shuming Jiao¹, Manhong Yao², Xiang Li², Jingang Zhong²; ¹Shenzhen Univ., China; ²Jinan Univ., China. In previous works, encrypted single pixel imaging (SPI) systems are usually implemented with random illumination patterns. We propose an encrypted SPI system using permuted Hadamard basis patterns, which enables high-quality and efficient encrypted single-pixel imaging.

CTu2E.4 • 11:00

Correlation Matrix Estimation from Compressed Measurements in a Pattern Recognition System, Kevin A. Arias², Tatiana Gelvez¹, Jonathan Arley Monsalve Salazar², Henry Arguello²; ¹Dept. of Electrical Engineering, Universidad Industrial de Santander, Colombia; ²Computer Science, Universidad Industrial de Santander, Colombia. This paper uses compressive sensing theory to reduce the dimensionality of the correlation matrix estimation in a pattern recognition system. Results show that the correlation matrix can be effectively estimated from compressed measurements using a sparse-based reconstruction algorithm.

CTu2E.5 • 11:15

Exploiting Inter Voxel Correlation in Compressed Computational Imaging, Naren Viswanathan¹, Suresh Venkatesh¹, David Schurig¹; ¹ECE, Univ. of Utah, USA. An ensemble of representative targets contains a priori correlation information, quantified by the intervoxel covariance matrix. Thresholding according to the eigenvalues of this matrix and reconstructing only those eigenmodes, a faster, more accurate reconstruction is obtained.

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

Tangerine

Propagation Through and Characterization
of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DTu2F • Contemporary Topics in DH— Continued

DTu2F.3 • 10:45

Holographic see-through near-eye display using index-matched anisotropic crystal lens, Jong-Young Hong¹, Gang Li¹, Byoungcho Lee¹; ¹Seoul National Univ., South Korea. We propose the holographic display for see-through near-eye display using transmission type optical floater which is index-matched anisotropic crystal lens. By adopting transmission type optical floater, our system showed the possibility of the holographic display with large field of view.

DTu2F.4 • 11:00

Fast generation of holographic videos of a 3-D moving object based on a rotational-motion compensation method, Hongkun Cao¹, ShuFeng Lin¹, EunSoo Kim¹; ¹Kwangju Univ., South Korea. A curved-hologram-based rotational-motion compensation method is proposed for fast generation of holographic videos of a 3-D moving object. Experiments show the proposed method can dramatically enhance the computational speed of the conventional hologram-generation algorithms.

DTu2F.6 • 11:15

Two-stage Autofocusing Methodology for Digital Lensless Holographic Microscopy, Carlos A. Trujillo¹, Jorge Garcia-Sucerquia¹; ¹Univ Nacional de Colombia Medellin, Colombia. A two-stage methodology based on traditional techniques and the modified enclosed energy metric for autofocusing in digital lensless holographic microscopy is presented. The validation of the proposal has been performed with experimental holograms.

3Tu2G • HMD & VAC Solution—Continued

3Tu2G.3 • 11:00 Invited

An Adaptive Rendering for Microlens Array HMD based on Eye-Gaze Tracking, Hirokazu Kato¹, Alexander Plopski¹, Takafumi Taketomi¹, Christian Sandor¹; ¹Nara Inst. of Science and Technology, Japan. Microlens Array HMDs require adaptive rendering based on eye-gaze tracking to show clear images to the user because of the small eye box. In this talk, we will explain our ideas about this issue.

STu2H • Components I—Continued

STu2H.3 • 11:00 Invited

Compact Steering Technologies for Automotive LiDAR: a Comparison Between Liquid Crystal Clad Waveguides and Optical MEMs, Scott R. Davis¹, Andrew W. Sparks¹, Laura Fegely¹, Kemiao Jia¹, Derek Gann¹; ¹Analog Devices, Inc., USA. Compact, rugged, low power, and affordable laser beamsteering devices are desired to enable light detection and ranging (LiDAR) for advanced driver-assistance systems (ADAS). We have considered both MEMs and LC-clad waveguide technologies. The tradeoffs between the two will be presented.

PTu2I • Propagation Simulations— Continued

PTu2I.3 • 10:45

Image Reconstruction with Active Illumination in Strong Turbulence Scenarios, Venkata S. Gudimetla¹, Richard Homes²; ¹US Air Force, USA; ²Boeing LTS, USA. Three fast-running reconstruction algorithms based on single-frame processing are compared up to Rytov variances of 0.4 over a 30 km range with an isoplanatic patch comparable to the diffraction angle, and many patches across the object.

PTu2I.4 • 11:00

Discrepancies between Simulation and Theory Results for Plane Wave Scintillation in Atmospheric Turbulence, Erandi A. Wijerathna¹, David Voelz¹, Hanyu Zhan¹; ¹New Mexico State Univ., USA. The scintillation index for a plane wave in weak to deep turbulence is studied with wave optics simulations for several atmospheric spectrum models. The simulations generally predict peak scintillation values for $\sigma_R \approx 2$ and comparisons with analytical theory show the simulations predict significantly higher scintillation, particularly for small inner scale values.

PTu2I.5 • 11:15

Propagation Simulation of Higher Order Bessel Beams Integrated in Time (HOBBIT), Joseph Watkins¹, Keith Miller¹, Wenzhe Li¹, Kaitlyn Morgan¹, Eric G. Johnson¹; ¹Clemson Univ., USA. The paper presents simulation results from the propagation of dynamic HOBBITs through a series of moving phase screens representing turbulence.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

Orange/Lemon/Lime

Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATu2A • Keynote and Laser Sorcery—Continued

DEMO

T-Cavity VECSELs developed by TPhotonics Inc. and the University of Arizona allow for the generation of tunable two-color emission, sum and difference frequency generation, and also orbital angular momentum beams. We will demo our first-generation VECSEL lasers which operating at room temperature with no water cooling.

ITu2B • Microscopy I: Super-resolution & Illumination Techniques—Continued

ITu2B.6 • 11:30
Imaging and Quantitating Abrasion Damage on Transparent Substrates Using Edge Light Illumination, Christine Cecala¹, Evan Bittner¹, Eric Null¹; ¹Corning Incorporated, USA. A system was developed to characterize surface damage on samples subjected to abrasion testing. It is optimized to correlate directly with human visual rankings while providing repeatable quantitation of damage.

LTu2C • Combustion Diagnostics I—Continued

LTu2C.6 • 11:45
An improved TDLAS technique to measure residence time distributions in particle loaded combustion chambers, Sebastian Bürkle¹, Lukas G. Becker¹, Andreas Dreizler¹, Steven Wagner¹; ¹TU Darmstadt FG RSM, Germany. A technique to measure residence time distributions in chemical reactors without the need of modelling by using pulse-injections of HCl with TDLAS-detection is presented and demonstrated under non-reacting and reacting conditions in an oxy-coal/oxy-gas combustor.

MTu2D • High-Dimensional Imaging—Continued

MTu2D.5 • 11:30
Using the Pupil-Difference Probability Density to Understand OTF, Kevin Liang^{1,2}, Miguel A. Alonso^{1,2}; ¹Inst. of Optics, USA; ²Center for Freeform Optics, USA. We provide an overview of the pupil-difference probability density (PDPD) and its connection to the OTF. We then illustrate its use in understanding the effects of mid-spatial frequency (MSF) structures and quadratic surface errors.

MTu2D.6 • 11:45
Spatial Intensity Averaging for Ghost Imaging With a Single-Port Dynamic Metasurface Aperture, Aaron V. Diebold¹, Mohammadreza F. Imani¹, Timothy Sleasman¹, David Smith¹; ¹Duke Univ., USA. We present a method for achieving spatial intensity integration of temporally coherent microwave radiation. The approach consists of averaging the instantaneous intensity over an ensemble of random radiation patterns using a single-port metasurface aperture.

CTu2E • Compressive Sensing 1—Continued

CTu2E.6 • 11:30
Double-threshold Denoising for Single-pixel Camera, Chao Wang^{1,2}, Xuri Yao¹, Qing Zhao²; ¹National Space Science Center, Chinese Academy of Sciences, China; ²Beijing Inst. of Technology, China. Present a method that sets two thresholds to select the measurement data for image reconstruction of Single-pixel camera. The results show that the proposed double-threshold compressive imaging protocol provides better image quality than previous schemes.

CTu2E.7 • 11:45
Multi-object Recognition in Turbid Water Using Compressive Sensing, Changqing Dong^{1,3}, Xuemin Cheng^{1,3}, Hongsheng Bi^{1,3}, Qun Hao²; ¹Tsinghua Univ., China; ²School of Optics and Photonics, Beijing Inst. of Technology, China; ³Graduate School at Shenzhen, Tsinghua Univ., China; ⁴Chesapeake Biological Lab, Univ. of Maryland Center for Environmental Science, USA. Recognizing and classifying plankton in low-contrast images is difficult. A clustering algorithm are proposed to classify plankton and counted them on a compressed sensing frame. The reasonable output is proved in the experiment.

12:00–13:30 Light the Future Lunch, Palm Foyer

12:30–14:00 Student & Early Career Professional Development & Networking Lunch and Learn, Jasmine

Citron

Digital Holography & 3-D Imaging

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3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

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DTu2F • Contemporary Topics in DH— Continued

DTu2F.7 • 11:30

Terahertz pulse time-domain holography for studying of broadband beams propagation dynamics, Nikolai V. Petrov¹, Victor G. Bespalov¹, Maksim S. Kulya¹; ¹*ITMO Univ., Russia*. In given talk we consider the possibilities of terahertz pulse time-domain holography for the spatio-temporal and spatio-spectral analysis of arbitrary broadband beams basing on the spatio-temporal field distribution measured in one transversal plane.

3Tu2G • HMD & VAC Solution—Continued

3Tu2G.4 • 11:30

Super Multi-View Near-Eye Display Using Time-Multiplexing Technique, Takaaki Ueno¹, Yasuhiro Takaki¹; ¹*Tokyo Univ. of Agri. & Tech., Japan*. A super multi-view near-eye display is proposed to solve the vergence-accommodation conflict. A ferroelectric liquid crystal display and an LED array were combined to generate viewpoints two-dimensionally in a time-multiplexing manner. The prototype was demonstrated.

3Tu2G.5 • 11:45

A Continuous Variable Lens System to Address the Accommodation Problem in VR and 3D Displays, Afsoon Jamali¹, Comrun Yousefzadeh¹, Colin McGinty¹, Douglas Bryant¹, Philip Bos¹; ¹*Kent State Univ., USA*. We propose a hybrid system design comprised of refractive Fresnel and Pancharatnam-Berry LC lenses resulting in a compact, large aperture, fast and tunable optic that can be used in numerous applications including VR/3D systems.

STu2H • Components I—Continued

STu2H.4 • 11:30

High-speed pulse control and optimization of quantum cascade laser using all-optical modulation, Chen Peng¹, Haijun Zhou², Tao Chen¹, Biao Wei², Zeren Li¹; ¹*Inst. of Fluid Physics, China Academy of Engineering Physics, China*; ²*Chongqing Univ., China*. Pulse control and optimization are demonstrated in a standard middle-infrared quantum cascade laser via an all optical approach. It has the potential for application in free space optical communication and high speed frequency modulation spectroscopy.

PTu2I • Propagation Simulations— Continued

PTu2I.6 • 11:30

Investigating Polarization Singular Beams for Robust Propagation Through a Random Medium, Priyanka Lochab¹, Kedar Khare¹, Paramsivam Senthilkumaran¹; ¹*Indian Inst. of Technology Delhi, India*. Beams carrying C-point polarization singularity (lemon and star) are experimentally shown to maintain robust intensity profile on passing through a random medium compared to beams carrying V-points polarization singularity (radially and azimuthally polarized).

PTu2I.7 • 11:45

High Energy Laser Propagation: Environmental Effects, Dana Morrill¹, Benjamin Akers¹; ¹*Air Force Inst. of Technology, USA*. The environmental effects of high energy laser propagation are numerically simulated in a wave optics model coupled with direct simulation of the background fluid flow. The roles of fluid boundary conditions and scintillation are discussed.

12:00–13:30 Light the Future Lunch, *Palm Foyer*

12:30–14:00 Student & Early Career Professional Development & Networking Lunch and Learn, *Jasmine*

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Orange/Lemon/Lime

Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

13:30–15:30

ATu3A • Fiber Sensory Overload

Presider: Denis Donlagic; Univerza v Mariboru, Slovenia

ATu3A.1 • 13:30 Invited

FOSS: Recent Development Efforts and Paths to Commercialization, Hon Man (Patrick) Chan¹; ¹NASA Armstrong Flight Research, USA. An overview of FOSS technology developed at NASA based on OFDR is discussed in brief. Recent Deployments efforts, both in aerospace and beyond is demonstrated. Paths to commercialization with the public sector via NASA technology transfer office is also highlighted.

DEMO

Real Time Demonstration of NASA Armstrong Flight Research Center's next generation of Fiber Optics Sensing System (FOSS), based on Optical Frequency Domain Reflectometry (OFDR), showcasing strain distribution of a test coupon where a single fiber optics cable can have multiple fiber sensors composed of fiber bragg gratings (FBG).

ATu3A.2 • 14:15 Invited

Smart metallic part manufacturing by laser-cladding based embedding of optical fiber sensors, Ander Zornoza¹, Tania Granda^{1,2}; ¹AIMEN, Spain; ²school of mathematics, Computer science and engineering, City Univ. of London, UK. Laser based additive manufacturing of metal parts has opened the path to embedding fiber optic sensors that withstand the harshness of the process and applications, since the technique allows many degrees of freedom. As a promising solution laser cladding based embedding of metal coated fiber optics into which Fiber Bragg Grating (FBG) sensors have been written are presented in this paper.

14:00–15:15

ITu3B • Microscopy II: 3D & High Speed Techniques

Presider: Rajesh Menon; Univ. of Utah, USA

ITu3B.1 • 14:00 Invited

Compressive high-speed imaging in fluorescence microscopy and 3D photography, Shuo Pang¹; ¹Univ. of Central Florida, CREOL, USA. We present the recent progress in compressive high-speed imaging systems based on spatiotemporal encoding. Specifically, the development in algorithms and new applications in fluorescence microscopy and 3D photography will be discussed.

ITu3B.2 • 14:30

Development of a coded exposure camera for high-speed 3D measurement using microscope, Toshihiko Yamashita¹, Hiroyuki Chiba¹, Kazuki Yamato¹, Hiromasa Oku¹; ¹Gunma Univ., Japan. This paper propose a coded exposure camera for high-speed 3D measurement using microscope and a tunable acoustic gradient index lens. Experimental results showed the validity of the proposed camera.

13:30–15:30

LTu3C • Combustion Diagnostics II

Presider: Christoph Arndt; German Aerospace Center (DLR), Germany

LTu3C.1 • 13:30 Invited

Wavelength-Modulation Spectroscopy in the Near-GHz Regime for High-Speed Thermometry and Species Sensing, Garrett Mathews¹, Christopher S. Goldenstein¹; ¹Purdue Univ., USA. This work presents the development and application of a novel wavelength-modulation spectroscopy technique for measuring gas temperature and H₂O concentration in combustion flows at rates approaching 1 MHz.

LTu3C.2 • 14:00

Two-line Kr PLIF technique for composition independent temperature imaging in gaseous combustion, Venkateswaran Narayanaswamy¹, Dominic Zelenak¹; ¹North Carolina State Univ., USA. A two-line Kr PLIF based thermometry technique will be presented for application in gaseous combustion. The technique uses the spectral line broadening of the krypton seeded into the fuel stream to provide 2D temperature field.

LTu3C.3 • 14:15

Three-dimensional Temperature Measurements in Turbulent Reacting Flows, Paul S. Hsu¹, Benjamin R. Halls², Sukesh Roy¹, Terrence Meyer³, James R. Gord²; ¹Spectral Energies LLC, USA; ²Air Force Research Lab, USA; ³Purdue Univ., USA. We demonstrated single-shot, three-dimensional temperature field measurements in a turbulent hydrogen-air flame using two-color hydroxyl radical volumetric laser-induced fluorescence (OH-VLIF). Four high-speed intensified cameras with shared quadscopes were used for tomographic temperature field imaging.

LTu3C.4 • 14:30 Invited

Thermometry and barometry in combustion using laser induced gratings, Paul Ewart¹; ¹Univ. of Oxford, UK. Laser-induced grating spectroscopy for temperature and pressure measurements in combustions and non-combusting flows with time- and space-resolution are reviewed for applications in gasoline and diesel engines and other environments.

13:30–15:30

JTu3D • 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman I

Presider: Edmund Lam; Univ. of Hong Kong, Hong Kong

JTu3D.1 • 13:30 Invited

Origins and Evolution of Introduction to Fourier Optics, Joseph W. Goodman¹; ¹Stanford Univ., USA. In this talk I trace the history of Introduction to Fourier Optics, from inception to the 4th edition. Also discussed are foreign editions, numbers of books sold, citations, and other facts about the book.

JTu3D.2 • 14:00 Invited

What's the Problem? Insight and Inspiration Derived from Solving the Exercises in J. Goodman's Classic Book Introduction to Fourier Optics, James Leger¹; ¹Univ. of Minnesota Twin Cities, USA. The exercises contained in Goodman's classic text have delighted students and researchers for 50 years. In this talk, we explore the impact of these elegant problems on pedagogy and research. We describe how these exercises have provided insight to beginning students and inspiration to practicing optical engineers.

JTu3D.3 • 14:30 Invited

The Transition of Fourier Optics Towards Computational Imaging and Digital Holography, Demetri Psaltis¹; ¹Ecole Polytechnique Federale de Lausanne, Switzerland. I will trace the remarkable robustness of the Fourier Optics described in Goodman's book from the analog optical systems 50 years ago to the digital techniques that are widely used in optics today.

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free Space Communication

Tangerine

Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

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13:30–15:30

3Tu3E • Compressing & Integral Imaging Sensing (Light Field)

Presider: Adrian Stern; Ben Gurion Univ. of the Negev, Israel

3Tu3E.1 • 13:30 **Invited**

Densely-sampled light field: reconstruction, compression and applications, Atanas Gotchev¹; ¹Tampere Univ. of Technology, Finland. Densely-sampled Light Field is an attractive representation of scene visual content facilitating arbitrary ray interpolation and view synthesis. We discuss its effective reconstruction from sparse multi-perspective views, compression and applications in microscopy and full-parallax imaging.

3Tu3E.2 • 14:00 **Invited**

Smart optics for low-power computational sensing, David Stork¹; ¹Rambus Labs, USA. Special diffraction gratings can structure incoming light so that fewer pixels need be read for a criterion sensor performance, thus reducing the power dissipation in some simple optical sensors.

3Tu3E.3 • 14:30 **Invited**

Light-field background de-cluttering for visual prostheses, Jae-Hyun Jung^{1,2}, Eli Peli^{1,2}; ¹Harvard Medical School, USA; ²Ophthalmology, Schepens Eye Research Inst., USA. Object recognition is challenging with current visual prostheses, especially with background clutter. We have developed an imaging system to remove the background clutter in the visual prostheses using the light-field camera and bipolar edge filtering.

14:30–15:30

STu3F • Quantum Protocols I

Presider: Robert Boyd; Univ. of Ottawa, Canada

STu3F.1 • 14:30 **Invited**

Weak Value Amplification: What is it and is it useful?, Jeff S. Lundeen¹; ¹Physics, Univ. of Ottawa, Canada. Weak value amplification is a general technique that magnifies the effect of a measured parameter. It has enabled astounding sensitivity, for instance a 560 femtoradian mirror tilt. I will outline when WVA is useful.

14:15–15:30

PTu3G • Underwater Propagation

Presider: Olga Korotkova; University of Miami, USA

PTu3G.1 • 14:15 **Invited**

Airborne Lidar Characterization of Oceanic Phenomena, James H. Churnside¹; ¹Earth System Research Lab, NOAA, USA. Airborne polarization lidar has been used to characterize a variety of oceanic phenomena. Physical phenomena, such as internal waves and turbulence, were observed by tracking scattering layers at density gradients in the upper ocean.

Sunset/Fleming

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Joint

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ATu3A • Fiber Sensory Overload—
ContinuedATu3A.3 • 14:45 **Invited**

In-situ Continuous Measurement of Pressure Pulsations at 650C with Fiber Optic Sensor, John W. Berthold¹, Richard L. Lopushansky¹; ¹*Davidson Instruments, Inc., USA*. We describe a system to measure combustion instabilities in gas turbine engines used for electrical power generation. The sensor is an extrinsic fiber optic Fabry-Perot interferometer packaged in a 6mm diameter probe that is permanently positioned within the engine near the combustor.

DEMO

The presentation will include a show-and-tell with one or more Davidson Instruments sensor probes that may be inspected by session attendees. The configuration of these typical probes that are used to monitor combustion dynamics in gas turbine combustors in the electric power generation industry will be described.

ITu3B • Microscopy II: 3D & High Speed
Techniques—Continued

ITu3B.3 • 14:45

Depth of Focus Extension based on a Laser Frequency-shifted Feedback Imaging System, Yueyue Lu¹, Kaiyi Zhu¹, Shulian Zhang¹, Yidong Tan¹; ¹*Dept. of Precision Instrument, Tsinghua Univ., The State Key Lab of Precision Measurement Technology and Instrument, China*. A laser frequency-shifted feedback imaging configuration is demonstrated whose depth of focus is extended to twice the focus length of the objective lens. Images on any planes can be refocused from one defocus image.

ITu3B.4 • 15:00

Temporal Study of Photonic Jet Formations under Ultrashort Laser Pulses Illumination for Different Geometries in Near-field Optical Microscopy, Charles Pichette¹, Michel Piché¹, Pierre Marquet^{2,1}, Simon Thibault¹; ¹*Université Laval, Canada*; ²*Cervo Brain Research Center, Canada*. Near-field optical microscopy is a superresolution technique relying on photonic jets (PJs) with sub-diffraction limit focusing as illumination. The temporal and spectral characteristics of these PJs under ultrafast illumination is investigated here for different geometries.

LTu3C • Combustion Diagnostics II—
ContinuedLTu3C.5 • 15:00 **Invited**

Time-resolved digital in-line holography and pyrometry for aluminized solid rocket propellants, Yi Chen¹, Jeffery Heyborne¹, Daniel R. Guildenbecher¹; ¹*Sandia National Labs, USA*. Combustion of aluminum droplets in solid rocket propellants is studied using laser diagnostic techniques. The time-resolved droplet velocity, temperature, and size are measured using high speed digital in-line holography and imaging pyrometry at 20kHz.

JTu3D • 50th Anniversary of Introduction
to Fourier Optics by Joseph Goodman I—
ContinuedJTu3D.4 • 15:00 **Invited**

Linear-Algebra Optics, Bahaa Saleh¹; ¹*Univ. of Central Florida, USA*. Fourier and linear systems methods are indispensable tools of optics. Matrix methods are necessary to describe discrete optical systems, such as polarization and ray optics. A more general approach based on linear algebra and vector spaces is necessary to address the full spectrum of topics in classical optics.

15:30–16:30 Coffee Break with Exhibitors, Palms Foyer

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free Space Communication

Tangerine

Propagation Through and Characterization of Atmospheric and Oceanic Phenomena

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3Tu3E • Compressing & Integral Imaging Sensing (Light Field)—Continued

3Tu3E.4 • 15:00

Plenoptic Tomographic Imaging of Fluorescent Probes – Instrumentation Blueprint, Jörg Peter¹, Mark E. Ladd¹; ¹German Cancer Research Center, Germany. We report on the development and simulation results of a plenoptic camera and tomography system designed for in vivo bioluminescence and multispectral fluorescence imaging. The system is intended for synchromodal use in secondary imaging modalities.

3Tu3E.5 • 15:15

Depth Estimation and Multi-view Spectral Image Based on Compressive Sensing Light Field Reconstruction, Xiaomin Liu¹, Qiancheng Wang¹, Zhibang Ma¹, Yuanye Niu², Shaoli Duan³, Huaping Zang¹, Fengying Ma¹, Min Huang⁴, Qunbo Lv⁴, Erjun Liang¹; ¹Zhengzhou Univ., China; ²Zhengzhou Xin da Inst. of Advanced Technology, China; ³Kunming Inst. of Physics, China; ⁴Academy of Opto-Electronics, Chinese Academy of Sciences, China. Based on compressive sensing, multi-views light field images were reconstructed both simulating and physical implementing. LF-image depth estimation with multi-clue fusion was realized. And multi-view true color images were generated synthesized through spectral data.

STu3F • Quantum Protocols I—Continued

STu3F.2 • 15:00 Invited

Quantum Key Distribution (QKD) Using Full Laguerre-Gauss Encoding, Robert W. Boyd^{1,2}; ¹Univ. of Ottawa, Canada; ²Inst. of Optics, Univ. of Rochester, USA. We describe progress in developing a free-space QKD system that encodes information in both the radial and azimuthal degrees of freedom. Such a system makes optimum use of the sizes of sending and receiving telescopes.

PTu3G • Underwater Propagation—Continued

PTu3G.2 • 14:45

Mapping the Attenuation Coefficient in Yellowstone Lake, Yellowstone National Park, USA, Michael R. Roddewig^{1,2}, James H. Churnside³, Joseph A. Shaw¹; ¹Montana State Univ., USA; ²AdvR, Inc., USA; ³Earth Systems Research Lab, NOAA, USA. We introduce a spatial and temporal study of the lidar attenuation coefficient from a series of airborne lidar flights conducted in 2015 and 2016 over Yellowstone Lake, Yellowstone National Park, Wyoming, USA. We then relate these data to the Secchi disk depth, discuss the possible impact that local weather may have had on the attenuation coefficient, and compare these data to the modeled lidar attenuation coefficient.

PTu3G.3 • 15:00

Sensitivity Study on the Effect of the Optical and Physical Properties of Coated Spherical Particles on the Underwater Linear Polarization Pattern, Masada Tzabari¹, Carynelisa Haspel¹; ¹The Fredy and Nadine Hermann Inst. of Earth Sciences, The Hebrew Univ. of Jerusalem, Israel. The influence of coated spherical hydrosols on the polarization characteristics (e.g., the degree of linear polarization and E-vector angle) of light refracted at the air-water interface followed by single scattering is investigated.

PTu3G.4 • 15:15

Experiments with non-uniformly correlated laser beams propagating underwater, Svetlana Avramov-Zamurovic¹, Milo Hyde², Charles Nelson¹; ¹USNA, USA; ²AFIT, USA. Generation and underwater propagation of recently developed non-uniformly correlated laser beams is presented. The experimental set-up and initial observations of the beam intensity after a short underwater path are given.

15:30–16:30 Coffee Break with Exhibitors, Palms Foyer

Tuesday, 26 June

JTu4A.1

Interactive Multi-plane Display, Youngmin Kim¹, Jisoo Hong¹, Sunghye Hong¹, Choonsung Shin¹, Hy-eong-Hak Ahn¹, Elena Stoykova^{2,1}, Hoonjong Kang¹; ¹Korea Electronics Technology Inst., South Korea; ²Inst. of Optical Materials and Technologies, Bulgarian Academy of Science, Bulgaria. Interactive multi-plane display by using plural high-definition panels and transmissive dihedral corner reflector array plate was proposed. The observer could interact with floated multiple image planes.

JTu4A.2

Rapid calculation of full-color holographic system with real objects using relocated point cloud gridding method, Yu Zhao¹, Md-Sifatul Islam¹, Shahinur Alam¹, Seok-Hee Jeon², Nam Kim¹; ¹Chungbuk National Univ., South Korea; ²Incheon National Univ., South Korea. We propose a relocated-point cloud gridding method to accelerate the full-color holographic system with real objects. The proposed method reduces the huge computational costs associated with full-color hologram generation and the reconstructed results are excellent.

JTu4A.3

Coded aperture structured illumination digital holographic microscopy, Yu-Chih Lin¹, Xin-Ji Lai¹, Han-Yen Tu², Chau-Jern Cheng¹; ¹National Taiwan Normal Univ., Taiwan; ²Dept. of Electrical Engineering, Chinese Culture Univ., Taiwan. This work proposes and experimentally demonstrates coded aperture structured illumination digital holographic microscopy for resolution enhancement. The binary codes are applied for spatial phase shifting along with compressive sensing for retrieving the missing data.

JTu4A.4

Reduction of Visual Discomfort in HMD using Image Refocusing linked to Depth Control, Gwangsoon Lee¹, Joonsoo Kim¹, Won-Sik Cheong¹, Jeonil Seo¹, Jae-Hyeung Park²; ¹Electronics and Telecom Research Inst, South Korea; ²Inha Univ., South Korea. This paper proposes an image refocusing algorithm that can reduce the visual discomfort in stereoscopic HMD. Specifically, our image refocusing is optimized to emulate human vision and conducted by taking into consideration the control of perceived depth.

JTu4A.5

Measurement of angular dependence of emissivity through photothermal effect, Yaqi Zhang¹, Gerald Diebold¹; ¹Brown Univ., USA. The angular dependence of emissivity is obtained indirectly by measuring absorption through photothermal effect. Absorption of light induces thermal deformation and then electric charge generation. Angular dependence of emissivity of graphite and copper are given.

JTu4A.6

LED based Off-axis Reflection Digital Holographic Microscopy using Holographic Optical Element, Byounghyo Lee¹, Dukho Lee¹, Byoungcho . Lee¹; ¹Seoul National University, South Korea. We present compact off-axis reflection digital holographic microscopy that can image specimens using LED. Reflection holographic optical element is implemented to replace classical interferometer and make signal and reference wave follow the common optical path length to obtain interference pattern.

JTu4A.7

High-Sensitivity Measurement of Environmental NO₂ by Laser Photoacoustic Spectroscopy, Weidong Chen¹; ¹Universite du Littoral, France. A photoacoustic spectroscopy based NO₂ sensor was developed for measurement of ambient NO₂ with a sensitivity of about 0.4 ppb (SNR=1) in 1 min, which was validated with side-by-side measurements using a referenced NOx analyzer.

JTu4A.8

Evaluation of De-Noising Algorithms for Amplitude Image Restoration in Digital Holography, Silvio Montresor¹, Pascal Picart¹; ¹LAUM CNRS Le Mans Université, France. This paper presents the analysis of de-noising algorithms for images from digital holography. A set of 20 experimental images with SNR diversity are processed by 34 de-noising algorithms. Algorithms are ranked using appropriate metrics.

JTu4A.9

Dynamic holographic video projection based on upconversion material screen and LCos-SLM, Wen Zhou¹; ¹Shanghai Univ., China. A dynamic holographic three-dimensional (3D) projection based on liquid crystal on silicon spatial light modulator (LCos-SLM) and upconversion material is introduced. This work is to make the dynamic holographic video can be observed strictly on the upconversion material. And we also have done some work on the analysis of the image light field distribution in the upconversion material.

JTu4A.10

Performance Evaluation of Sparseness Significance Ranking Measure (SSRM) on Holographic Content, Ayyoub Ahar^{1,2}, Tobias Birnbaum^{1,2}, David Blinder^{1,2}, Athanasia Symeonidou^{1,2}, Peter Schelkens^{1,2}; ¹Vrije Univ. Brussel (VUB), Belgium; ²imec, Belgium. The Sparseness Significance Ranking Measure (SSRM) is a new quality measure for regular images. Here, we evaluate its performance on holographic content compared to MSE, PSNR and VSM. Results show a significant gain over the classical methods.

JTu4A.11

3D MTF for the Image Quality Assessment of Holographic Display System, Joongki Park¹, Eun-Young Chang¹, Hayan Kim¹, Jae-Han Kim¹, Jinwoong Kim¹, Minsik Park¹; ¹ETRI, South Korea. We propose a 3D MTF measurement method as a quantitative evaluation method for image quality of holographic displays. We show the experimental result of our tabletop holographic display by exploiting the proposed method.

JTu4A.12

Integral image pick-up based dynamic control holographic display system, Yan-Ling Piao¹, Young-Tae Lim¹, Ki-Chul Kwon¹, Nam Kim¹; ¹Chungbuk National Univ., South Korea. The real-existing scenes acquisition for hologram generation still have serious problem. In this research, an efficient CGH scheme that using Integral image pick-up system and dynamic control holographic display system is proposed.

JTu4A.13

A Novel Polarized Optical Flow Algorithm for Bionic Polarization Navigation Using in the Glimmer Light, Le Guan^{1,2}, Sheng Liu¹, Shiqi Li¹, Liyuan Zhai¹, Jinkui Chu¹, Yan Cui¹, Huikai Xie²; ¹Key Lab for Micro/Nano Technology and System of Liaoning Province, Dalian Univ. of Technology, China; ²Dept. of Electrical and Computer Engineering, Univ. of Florida, USA. A novel optical flow algorithm combining the polarization imaging technique is proposed to apply in the new type of polarization navigation sensor, which can output the velocity information around the clock.

JTu4A.14

Improvement of Signal and Contrast Ratio by Optimizing Spatially Offset Raman Spectroscopy System, Qiushi Liu¹, Xiaohua Zhang¹, Baozhen Zhao¹; ¹CIAE, China. By optimizing SORS system, the signal intensity increased about 3 times and the contrast ratio enhancement was about 2 times. The detection of subsurface components under the opaque medium was successfully achieved.

JTu4A.15

Adaptive Multi-Frequency Phase Stepping for Optimal 3D Depth Reconstruction, Jostein Thorstensen¹, Jens Thielemann¹; ¹Smart Sensor Systems, SINTEF Digital, Norway. We propose a 3D measurement algorithm based on Multi-Frequency Phase Stepping, using a single period pattern and a higher frequency pattern. An experimentally verified analytical expression for depth precision enables adaptive selection of the high frequency, ensuring optimal depth precision.

JTu4A.16

Recording Multiple Holographic Gratings in Nickel ion Doped Photopolymer Material Using Angle Multiplexing, Aswathy G¹, Rajesh C.S¹, Cheranellloor S. Kartha¹; ¹Physics, CUSAT, India. Feasibility of recording multiple holographic gratings in the same volume of the nickel ion doped photopolymer material was checked. Fifteen gratings with different resolutions were recorded in the same location using angle multiplexing technique.

JTu4A.17

Quasi-1D High-Speed Raman/Filtered Rayleigh Scattering for Combustion Dynamics Applications, Gaetano Magnotti¹, Yedhu Krishna¹; ¹CCRC, KAUST, Saudi Arabia. Raman/Rayleigh scattering is a powerful diagnostics technique to measure temperature, species and their gradients in non-sooting jet flames, but it is typically limited to repetition rates of 10 Hz or lower and to open jet configurations. Here we introduce a novel approach to extend sampling rates to 10 kHz, while maintaining the high accuracy and precision needed in experimental datasets intended for validation of numerical combustion models.

JTu4A.18

Measurement of glucose concentrations inside agar using parametric standing wave to realize non-invasive blood glucose sensor, Tomoya Kitazaki¹, Natsumi Kawashima¹, Naoyuki Yamamoto¹, Hiroyuki Nomura¹, Akira Nishiyama¹, Kenji Wada¹, Ichiro Ishimaru¹; ¹Kagawa Univ., Japan. To realize a noninvasive blood glucose sensor, we propose a method to generate reflection planes inside agar using ultrasonic standing waves. This method allows measurement of the glucose concentrations inside agar samples using mid-infrared spectroscopy.

JTu4A.19

Microscopic Shape from Focus using White Light Interferometric Fringes, Hernando Altamar-Mercado¹, Alberto Patiño-Vanegas¹, Andres G. Marrugo²; ¹*Facultad de Ciencias Basicas, Universidad Tecnologica de Bolivar, Colombia*; ²*Facultad de Ingenieria, Universidad Tecnologica de Bolivar, Colombia*. In this work we study the use of a focus measure to improve the 3D reconstruction of low reflectivity microscopic samples using white light interference microscopy. Simulation and experimental results show the improved reconstruction.

JTu4A.20

IR Polarization for Natural Clutter Suppression, Francis P. Pantuso¹, Collin J. Bright¹, Richard W. Harr¹, Michael P. Polcha¹, Aaron S. LaPointe¹; ¹*Night Vision and Electronics Sensors Dir, USA*. IR Polarization can help to find man-made objects in scenes primarily made up of the natural environment. A model was developed to predict and explain results in short range, on-the-move situations. Test results show that Polarization contrast nearly always exceeds radiance contrast and generally suppresses background clutter.

JTu4A.21

The first result of Compressed Channeled Imaging Spectropolarimeter, Wenyi Ren^{1,2}, Chen Fu², Gonzalo R. Arce²; ¹*Northwest Agriculture and forestry Univ., China*; ²*Dept. of Electrical and Computer Engineering, Univ. of Delaware, USA*. We presented a compressed channeled imaging spectropolarimeter, which was designed based on the channeled spectropolarimeter and coded aperture snapshot spectral imager. The 2-D spatial, 1-D spectral and 4-D full Stokes polarization information can be obtained simultaneously.

JTu4A.22

Security Enhancement of Double Random Phase Encryption against Ciphertext Only Attack, Shuming Jiao¹, Zhaoyong Zhuang¹, Wenbin Zou¹, Xia Li¹; ¹*Shenzhen Univ., China*. Recently several ciphertext only attack methods are proposed to crack double random phase encryption (DRPE), revealing severe system security flaws. A security enhancement scheme for DRPE against these attacks is proposed in this paper.

JTu4A.23

Optical Nonlinear Image Encryption System using Optically Generated Biometric Phase Mask, Gaurav Verma¹, Aloka Sinha¹; ¹*Physics, IIT Delhi, India*. A new optical biometric phase mask generation process based on digital holography for nonlinear image encryption is presented for security and authentication. Computer simulations are performed to validate the effectiveness and feasibility of the proposed scheme.

JTu4A.24

Analysis of 3D Image Reconstruction for Spherical Object Using Convolutional Neural Network in Digital Holography, Wooyoung Jeong¹, Kyungchan Son¹, Wonseok Jeon¹, Hyunseok Yang¹; ¹*Yonsei Univ., South Korea*. 3D depth measurement of object using digital holography is difficult to be realized because of the wavelength shorter than the depth of the object. In this paper, 3D image reconstruction of spherical object for digital holography is analyzed using convolutional neural network.

JTu4A.25

Single Shot Digital Holographic Imaging through a Scattering Layer, Bhargab Das¹, Nandan S. Bisht³, R. V. Vinu², Rakesh K. Singh²; ¹*Cen. Sci. Ins. Org. (CSIO), India*; ²*Dept. of Physics, Indian Inst. of Space Science and Technology, India*; ³*Dept. of Physics, Kumaun Univ., India*. We present our recent research studies on single-shot complex amplitude information retrieval through a visually opaque scattering layer realized using different architectures based on speckle interferometry, intensity correlation interferogram, phase-retrieval algorithm and digital holography.

JTu4A.26

An Infrared Dim Small Target Detection Algorithm Based on Adaptive Lateral Inhibition and SVD, Yong Song¹, Yun Li¹, Shaokun Han¹, Xu Li¹, Yurong Jiang¹, Yufei Zhao¹, Shangnan Zhao¹; ¹*Beijing Institute of Technology, China*. This paper proposes an infrared dim small target detection algorithm based on adaptive lateral inhibition and singular value decomposition (SVD), which has relatively high detection rate and excellent abilities of background suppression and target enhancement.

JTu4A.27

An optical closure study of ethylene flame soot, Meng Wang¹, Yucun Liu¹, Arun Ramachandran², Ravi Varma², Huinan Yang¹, Mingxu Su¹, Jun Chen¹; ¹*School of energy and power engineering, USST, China*; ²*Physics, National Inst. of Technology, India*. An optical closure study of ethylene flame soot by combing Two-color laser-induced incandescence (LII) and cavity ring-down (CRD). Simulations and Lab measurements of the extinction coefficient showed good agreement with expected and reported values.

JTu4A.28

Measuring Flame Speeds with High Speed Imaging Diagnostics, Kenneth R. Bratton¹, Connor Woodruff¹, Loudon Campbell¹, Michelle Pantoya¹, Ronald Heaps²; ¹*Texas Tech Univ., USA*; ²*Idaho National Labs, USA*. Comparison of flame speed measurements of slow (cm/s) and fast (m/s) reacting powders utilizing various filtration and laser illumination techniques. Imaging techniques provide unique observations of energy propagation but no difference in average flame speed.

JTu4A.29

Investigation of flowing liquid film by diode laser absorption spectroscopy and ultrasonic pulse-echo method, Huinan Yang¹, Yuexing Zhang¹, Yong Jiang¹, Jun Chen¹, Mingxu Su¹; ¹*Univ. of Shanghai for Science and Technology, China*. Diode laser absorption spectroscopy (DLAS) and ultrasonic pulse-echo method (UPEM) were applied to investigate the flowing liquid film at different speeds, and it revealed that the parameters determined by both methods were in good agreement.

JTu4A.30

3D IC/Stacked Device Fault Isolation using Lock-in Infrared Microscopy, Hwan Hur¹, Kye-Sung Lee¹; ¹*Korea Basic Science Inst., South Korea*. A lock-in infrared microscopy for 3D IC/Stacked device fault detection is developed. The fault is localized in 3-dimension by the thermal difference of an amplitude image and depth estimation from phase image considering the thermal diffusivity.

JTu4A.31

Speckle suppression in off-axis lensless Fourier transform digital holography by LCOS, Jie Zhao¹, Dayong Wang¹, Spozmai Panezai¹, Yunxin Wang¹, Lu Rong¹; ¹*Beijing Univ. of Technology, China*. Speckle noise suppression in off-axis lensless Fourier transform digital holography by laterally shifting of object is analyzed quantitatively. LCOS spatial light modulator is used in object beam path to introduce the lateral shift in its position digitally without mechanical efforts.

JTu4A.32

Evaluation of phase shifting fringe patterns using iterative self-tuning demodulation method, Hubing Du¹; ¹*Xi'an Technological Univ., China*. We presents a method an iterative self-tuning phase-shifting algorithm for extracting the phase of three frame phase shifting fringe patterns with unknown phase step. The proposed method can be implemented easily in many applications.

JTu4A.33

Focal plane detection via holographic autofocusing criterion applied on Terahertz Time-domain spectroscopy system, Yuchen Zhao¹, Dinh T. Nguyen², Yves Hernandez², Marc P. Georges¹; ¹*Centre Spatial de Liège, STAR Research Unit, Liege Université, Belgium*; ²*Multitel A.S.B.L, Belgium*. Holographic autofocusing technique is applied on a terahertz time-domain spectroscopy system to improve focus accuracy. We experimentally perform the focus plane detection with TDS measurement. Amplitude and phase information at different wavelengths are exacted.

JTu4A.34

3-D Surface Profilometry by Direct Color-Fringe Identification and an Orthogonal Setup, Nadia Tornero Martínez¹, Gerardo Trujillo-Schiaffino¹, Marcelino Anguiano-Morales¹, Didia Patricia Salas-Peimbert¹, Luis Francisco Corral-Martínez¹, Ismael Arturo Garduño-Wilches¹; ¹*División de Estudios de Posgrado e Investigación, Instituto Tecnológico de Chihuahua, Mexico*. A new profilometry structured-light technique using an orthogonal system-setup is presented, based on color identification of a color-fringe pattern without employing mathematical-models, the topography of a surface is achieved with a precision of ± 0.5766 mm.

JTu4A.35

Nondestructive Metrology of the Process of Holographic Recording by Ellipsometry, Hao Jiang¹, Zhao Ma¹, Yonggui Liao¹, Haiyan Peng¹, Shiyuan Liu¹; ¹*Huazhong Univ. of Sci. and Tech, China*. Muller matrix ellipsometry is introduced as a nondestructive method to measure the fabrication process of grating upon holography, with which the exact widths and refractive indices, nanoparticle fractions of bright and dark regions are achieved.

JTu4A.36

Lensless holographic microscope of biological samples, Hanu Ram¹, Vaibhav B. Bansode¹, Renu John¹; ¹*Biomedical Engineering, Indian Inst. of Technology Hyderabad, India*. Lensless holographic microscopy shows high potential to be a practical point of care diagnostic tool due to its unique features like compactness, simple prototype, and portability. In this work, a deep violet (370nm, 10 nm FWHM) LED at low power is used as a low coherent light source for lensless 3-D holographic imaging of live cells and microparticles. An on-chip Fresnel hologram of the sample is recorded on a high-resolution CMOS camera and 3-D phase reconstruction has been performed eliminating the twin images using an optimization approach.

Salon FGHI

15:30–16:30
JTU4A • Poster Session II**JTu4A.37**

Enhancement of Low-light Images and Videos, Thangamani Veeramani¹; ¹*Wipro Limited, India*. Enhancing Low-light Images is very important for further processing such as Sign Recognition, Lane Detection, Surround View Generation and many other problems in the Advanced Driver Assistance Systems. This is also crucial for Consumer Applications such as Digital Cameras and Smart-phone Cameras. The current enhancement algorithms mostly rely on a Space-Invariant approach where the Contrast Enhancement is done on the entire image. Hence we propose a Space-Variant approach that can restore the entire image in the low-light context.

JTu4A.38

Lifting Wavelet Transform based Ultrasound Image Fusion scheme, Jayant Bhardwaj¹; ¹*Bhagwan Parshuram Inst of Tech, India*. A Wavelet transform(WT) called Lifting has been implemented for fusion of two ultrasound images. It is observed that this scheme has better performance over conventional scheme of Discrete Wavelet Transform (DWT).

JTu4A.39**Withdrawn****JTu4A.40**

Defocused Image Formation Model for Plenoptic Imaging, Yanqin Chen¹, Xin Jin¹, Qionghai Dai²; ¹*Graduate School at Shenzhen, Tsinghua Univ., China*; ²*Tsinghua Univ., China*. This paper proposes to extend the PSF matrix of plenoptic imaging systems at focused depth to desirable defocused depth by multiplying a defocus approximation matrix. This extension is beneficial for saving time and hardware memory.

JTu4A.41**Withdrawn****JTu4A.42**

Towards Perception-Inspired Numerical Measures of Compression Error in Digital Holograms of Natural Three-Dimensional Scenes, Taina M. Lehtimäki¹, Ronan G. Reilly¹, Thomas J. Naughton¹; ¹*Maynooth Univ., Ireland*. We report on a visual perception study to measure differences between numerical error in reconstructions from digital holograms of real-world objects that have undergone lossy compression, and the loss in quality perceived by human observers.

NOTES

Tuesday, 26 June

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Joint Imaging Systems and
Applications/ Adaptive Optics:
Methods, Analysis and Applications

Largo/Longboat

Laser Applications to Chemical,
Security and Environmental
Analysis

Cedar/Marathon

Computational Optical Sensing
and Imaging

Orange/Lemon/Lime

Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30

**ATu5A • Bridging Two Worlds -
Academics and Industry**
Presider: Gary Miller; NRL, USA

ATu5A.1 • 16:30 **Invited**
**Definition of Boundary Conditions and
Variables to Cross Borders**, Domink Ra-
bus, *RABUS TECH, Germany*. Innovation
today relies on the merger of technologies.
I am convinced that novel break-through
ideas can only be materialized using cross
discipline thinking, understanding, in-
depth knowledge, and expertise. Crossing
borders from industry to academia or
vice versa opens new paths, mind sets
and thought processes which are vital for
successful innovations.

Panel • 17:00

This panel discussion will explore the
challenges and advantages of working
concurrently in both academia and in-
dustry. While employment in each sector
has its own merits, having access to both
ecosystems can potentially have a greater
impact on the success of a company. Here,
we'll look at the issues surrounding this
duality from panelists who currently have
a foot in both worlds.

Panel

Dominik Rabus, *Rabus.Tech, Germany*
Cather Simpson, *The Photon Factory,*
University of Auckland, New Zealand
Adam Wax, *Lumetica, USA*

16:30–18:30

**JTu5B • Microscopy & Imaging
(IS/AO)**

Presider: John Girkin; *University of
Durham, UK*

JTu5B.1 • 16:30 **Invited**
**Wavefront Sensorless Aberration Correc-
tion with Multi Actuator Adaptive Lens in
Microscopy and Retinal Imaging**, Stefano
Bonora¹; ¹CNR-INFM, *Italy*. Multi actuator
adaptive lenses can replace deformable
mirrors in the correction of time variant ab-
errations. We will show the results obtained
on medium size telescopes and to improve
the stability of complex laser systems.

JTu5B.2 • 17:00

**Intravital multi-photon imaging through
intact highly scattering bone using
binary wavefront optimization**, Kayvan
Forouhesh Tehrani¹, Peter Kner¹, Luke
J. Mortensen¹; ¹Univ. of Georgia, *USA*.
Diffraction limited imaging of structures in
a highly scattering heterogeneous tissue
like bone is a non-trivial task. Here we
show binary wavefront optimization using
a genetic algorithm, for 2-photon imaging
of bone endogenous cells.

16:30–18:30

**LTu5C • Atmospheric &
Environmental Monitoring II**

Presider: Dennis Killinger; *Univ. of
South Florida, USA*

LTu5C.1 • 16:30 **Invited**
**Development of Highly Sensitive Quan-
titative Measurements of Nascent
Soot Particles in Flames by Coupling
Cavity-ring-down Extinction and Laser
Induced Incandescence for Improving
the Understanding of Soot Nucleation
Process**, Pascale Desgroux¹, Christopher
Betrancourt¹, Xavier Mercier¹; ¹PC2A- *Univ.
of Lille - CNRS, France*. The presentation
focuses on the recent advances obtained in
quantitatively detecting soot nanoparticles
of size 2-4 nm using Laser-induced incan-
descence. These particles are involved in
the soot nucleation process in sooting
flames.

LTu5C.2 • 17:00

**Compact and Lightweight Laser Diag-
nostic System for Portable Emission
Measurements of Passenger Cars**,
Luigi Biondo^{1,2}, Niels Göran Blume^{1,2},
Lisa Engel^{1,2}, Butrint Zumeri^{1,2}, Christian
Kalski³, Benjamin Dixel³, Steven Wagner^{1,2};
¹High Temperature Process Diagnostics,
Germany; ²Dept. of Reactive Flows and
Diagnostics, *Germany*; ³Automotive -
Technologie- und Umweltzentrum (TUZ),
TÜV Hessen, *Germany*. A mobile exhaust
gas measuring TDLAS-system was tested
on public roads. It is capable of in-situ
detection of CO₂ and H₂O, using multi-pass
cells at the tailpipe end, while electronic is
located inside the car.

16:30–18:30

**CTu5D • Compressive Sensing 2:
Spectral Imaging**

Presider: Paulo Silveira; *CDM Optics
Inc, USA*

CTu5D.1 • 16:30
**Covariance Matrix Estimation from Mul-
tiple Subsets in Compressive Spectral
Imaging**, Elkin D. Díaz Plata¹, Jonathan
Arley Monsalve Salazar¹, Andres Guerrero¹,
Henry Arguello¹; ¹Universidad Industrial de
Santander, *Colombia*. This paper introduc-
es an optimization problem to estimate the
covariance matrix from multiple subsets
of compressive measurements using ran-
dom projection matrices. The proposed
optimization is tested with computational
simulations for the DD-CASSI and SSCSI
optical architectures.

CTu5D.2 • 16:45
**Compressive Spectral Polarization
Imaging Using a Single Pixel Detector**,
Jorge L. Bacca¹, Andres Guerrero¹, Daniel
Molina¹, Ariolfo Camacho¹, Henry Arguel-
lo¹; ¹Universidad Industrial de Santander,
Colombia. This paper introduces the
compression of spectral polarization
images using a single pixel architecture.
The proposed technique allows to obtain
several compressive 2-D projections with
spatial, spectral and polarization coding.

CTu5D.3 • 17:00

**Subsampling Schemes for the 2D Nucle-
ar Magnetic Resonance Spectroscopy**,
Samuel E. Pinilla¹, Kareth León¹, Daniel
Molina¹, Ariolfo Camacho¹, Henry Arguel-
lo¹; ¹Universidad Industrial de Santander,
Colombia. This work analyses several
subsampling schemes to recover the
two-dimensional nuclear magnetic reso-
nance (2D NMR) spectrum. To validate the
performance of each scheme, subsampling
rates are varied and applied to different
2D NMR techniques: HMBC, HSQC, JRES,
COSY, and TOCSY. Simulation results show
that the optimal empirical subsampling
rate is 35%.

16:30–18:30

**JTu5E • 50th Anniversary
of Introduction to Fourier
Optics by Joseph Goodman II**

Presider: Edmund Lam; *Univ. of
Hong Kong, Hong Kong*

JTu5E.1 • 16:30 **Invited**
**Teaching Fourier Optics: What I do
Differently after 50 Years**, William T.
Rhodes¹; ¹Florida Atlantic Univ., *USA*. My
teaching of Fourier optics has evolved
since I first took Joe Goodman's course
50 years ago. I will speak briefly on various
aspects of the subject that I have added or
now treat differently in my own teaching.

JTu5E.2 • 17:00 **Invited**
**ABCD Matrix Analysis for Fourier-Op-
tics Imaging**, James R. Fienup¹; ¹Univ. of
Rochester, *USA*. Fourier optics analysis of
a general ABCD paraxial optical imaging
system is given, including the effects of an
aperture stop inside the system.

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

Tangerine

Propagation Through and Characterization
of Atmospheric and Oceanic Phenomena

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30

DTu5F • Computer-Generated Holograms

Presider: Michal Makowski, Poland

DTu5F.1 • 16:30 **Invited**

Volumetric display with holographic femtosecond laser accesses, Yoshio Hayasaki¹, Kota Kumagai¹; ¹Utsunomiya Univ., Japan. Volumetric displays with holographic two- and multi-photon excitations using a computer-generated hologram displayed on a liquid crystal spatial light modulator were demonstrated.

DTu5F.2 • 17:00

Calculation of Horizontal-Parallax-Only Holograms Using One-Dimensional Zone-Plates, Yoshitaka Takekawa¹, Yasuhiro Takaki¹; ¹Tokyo Univ of Agri and Tech, Japan. The calculation of horizontal-parallax-only holograms using two-line zone-plates is proposed. The proposed technique enables the efficient elimination of the conjugate image and the zero-order diffraction light using hologram reconstruction systems with the single-sideband filter.

16:30–18:30

3Tu5G • 360-degree Display and Perception

Presider: Yasuhiro Takaki; Tokyo Univ of Agriculture and Technology, Japan

3Tu5G.1 • 16:30 **Invited**

The retinal input during fixation: Binocular head/eye coordination at the fine scale, Martina Poletti¹; ¹Neuroscience, Univ. of Rochester, USA. In the periods between voluntary gaze shifts, the eyes continually drift following erratic trajectories. We report that these movements compensate for microscopic head movements to yield visual signals with specific characteristics on the retina.

3Tu5G.2 • 17:00 **Invited**

Optical Properties of Schematic Eye Models, Jim Schwiegerling¹; ¹Univ. of Arizona, USA. Various schematic eye models have been proposed in the optics literature. These models range from first order models to models incorporating aberrations and accommodation. This talk examines the capabilities and limitations of schematic eye models.

16:30–18:30

STu5H • Quantum Protocols II

Presider: Robert Boyd; Univ. of Ottawa, Canada

STu5H.1 • 16:30 **Invited**

Encoding quantum information on the full spatial bandwidth of photons, Mohammad Mirhosseini^{1,2}, Yiyu Zhou², Jiapeng Zhao², Seyed Mohammad Hashemi Rafsanjani³, Alan E. Willner^{5,2}, Robert W. Boyd^{2,4}; ¹Kavli Nanoscience Inst. and Thomas J. Watson, Sr., Lab of Applied Physics, California Inst. of Technology, USA; ²The Inst. of Optics, Univ. of Rochester, USA; ³Dept. of Physics, Univ. of Miami, USA; ⁴Dept. of Physics, Univ. of Ottawa, Canada; ⁵Viterbi School of Engineering, Univ. of Southern California, USA. Measuring the radial quantum number of single photons paves the way for utilizing the entire transverse structure of light by encoding classical and quantum information in polarization, orbital angular momentum, and the radial degree of freedom.

STu5H.2 • 17:00 **Invited**

Turbulence-Resistant Free Space Communication Using Vector Beams, Zhimin Shi¹, Brian Kantor¹, Ziyi Zhu¹, Alexander Fyffe¹, Darrick Hay¹; ¹Physics, Univ. of South Florida, USA. We propose a high-dimensional free space communication protocol using vector beams as the information carrier. We show both numerically and experimentally that our protocol is robust against atmospheric turbulence without the need of adaptive optics.

16:30–17:45

PTu5I • Propagation in Scattering Media

Presider: Svetlana Avramov-Zamurovic, US Naval Academy, USA

PTu5I.1 • 16:30 **Invited**

Measuring Atmospheric Scattering in 3D, Amit Aides¹, Yoav Y. Schechner¹, Vadim Holodovsky¹, Aviad Levis¹, Dietrich Althausen²; ¹Technion Israel Inst. of Technology, Israel; ²Remote Sensing of Atmospheric Processes, Leibniz Inst. for Tropospheric Research, Germany. To sense the volumetric distribution and microphysics of aerosols and cloud droplets in the 3D atmosphere, we develop passive multi-view scattering tomography. It uses a camera network or spaceborne views, augmented by Lidar.

PTu5I.2 • 17:00

Multilevel Phase Shift Keying using coherently coupled beams with Orbital Angular Momentum, Kaitlyn Morgan¹, Yuan Li¹, Wenzhe Li¹, Keith Miller¹, Joseph Watkins¹, Eric G. Johnson¹; ¹Clemson Univ., USA. This presentation will demonstrate an underwater free space optical link based on the phase modulation of coherently coupled OAM modes. The detection will be performed using passive optics in a correlation receiver optical setup.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Joint Imaging Systems and
Applications/ Adaptive Optics:
Methods, Analysis and Applications

Largo/Longboat

Laser Applications to Chemical,
Security and Environmental
Analysis

Cedar/Marathon

Computational Optical Sensing
and Imaging

Orange/Lemon/Lime

Joint

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

**ATu5A • Bridging Two Worlds -
Academics and Industry—
Continued**

**JTu5B • Microscopy & Imaging
(IS/AO)—Continued**

JTu5B.3 • 17:15

Adaptive Optics for Precise Cell Ablation in vivo, John M. Girkin¹, Charlotte Buckley², Mariana Torres-Carvalho¹, Laura Young¹, Sebastien Rider², John Mullins²; ¹Univ. of Durham, UK; ²QMRI, Edinburgh Univ., UK. We have combined adaptive optics and opto-genetics with single plane microscopy to ablate single or groups of cells. Results will be presented demonstrating cellular ablation in the heart and kidney.

JTu5B.4 • 17:30

3D Nanoscopy with Sub-50 nm Resolution Deep Inside Tissue Using Adaptive Optics, Xiang Hao¹, Edward Allgeyer³, Jacopo Antonello², Martin J. Booth², Joerg Bewersdorff¹; ¹Yale Univ., USA; ²Univ. of Oxford, UK; ³Univ. of Cambridge, UK. We have developed a novel adaptive optics strategy to expand the application of isoSTED nanoscopy to thick specimens. Our strategy recovers the aberration-free point-spread function and efficiently suppresses side-lobe contributions.

JTu5B.5 • 17:45

Two-Photon light-sheet microscope with adaptive optics in the illumination and detection path., Reto P. Fiolka¹, Dean Wilding²; ¹UT Southwestern, USA; ²Center for Systems and Control (DCSC), TU Delft, Netherlands. A light-sheet fluorescence microscope is presented that uses adaptive optics to enable diffraction limited imaging in Zebrafish embryos and tumor spheroids. Using two-photon excitation, a robust and sensorless wavefront optimization scheme is implemented.

**LTu5C • Atmospheric &
Environmental Monitoring II—
Continued**

LTu5C.3 • 17:15

QEPAS Trace Gas Analysis of Methane and Water Vapor using an Interband Cascade Laser and an effective FPGA Algorithm, Tobias Milde¹, Morten Hoppe^{1,2}, Herve Tatenguem¹, Wolfgang Schade³, Joachim Sacher¹; ¹Sacher Lasertechnik GmbH, Germany; ²Technische Hochschule Mittelhessen, Germany; ³Technische Universität Clausthal, Germany. Newly developed tunable single mode interband cascade laser diodes in the wavelength range around 3.0 μm are combined with the QEPAS technique for trace gas detection of CH₄ and H₂O.

LTu5C.4 • 17:30

Path-averaged Methane Sensing Using Range-resolving Chirped Laser Dispersion Spectroscopy, Yifeng Chen¹, Andreas Hangauer², Gerard Wysocki¹; ¹Princeton Univ., USA; ²Siemens AG, Corporate Technology, Germany. We report a path-averaged remote methane sensing system based on range-resolving chirped laser dispersion spectroscopy with 0.2m accuracy for path-length measurement and 2.7ppm-m/Hz^{1/2} sensitivity for concentration measurement.

LTu5C.5 • 17:45

Multiple-Species DIAL for H₂O, CO₂, and CH₄ remote sensing in the 1.98 – 2.30 μm range, Erwan Cadiou^{1,3}, Jean-Baptiste Dherbecourt¹, Myriam Raybaut¹, Guillaume Gorju¹, Jean-Michel Melkonian¹, Antoine Godard¹, Jacques Pelon²; ¹ONERA, France; ²LATMOS, France; ³CNES, France. We report on the experimental demonstration of a direct detection differential absorption LIDAR for CO₂, CH₄, and H₂O concentration measurement. It is based on a high energy parametric source tunable in the 2 μm region.

**CTu5D • Compressive Sensing 2:
Spectral Imaging—Continued**

CTu5D.4 • 17:15

Compressive coded LED and coded aperture spectral video system, Xiao Ma¹, Chen Fu¹, Gonzalo R. Arce¹; ¹Univ of Delaware, USA. A new compressive spectral video system is proposed to obtain a four dimensional (4D) spectral and temporal image signal. Coded aperture and spectral LEDs are introduced to give spatial and spectral modulations. We experimentally verified the 4D reconstruction performance of this proposed imager.

CTu5D.5 • 17:30

Spatial Super-resolution reconstruction via SSCSI Compressive Spectral Imagers, Edgar E. Salazar¹, Alejandro Parada¹, Gonzalo R. Arce¹; ¹ECE, Univ. of Delaware, USA. The spatial super-resolution concept is explored on the Spatial Spectral Compressive Hyperspectral Imager as a function of the coded aperture and detector pitch sizes and the coded aperture positions.

CTu5D.6 • 17:45

Snapshot Compressive Spectral+Depth Imaging with Color-Coded Apertures, Hoover Rueda¹, Daniel L. Lau², Gonzalo R. Arce¹; ¹Univ. of Delaware, USA; ²Dept. of Electrical and Computer Engineering, Univ. of Kentucky, USA. We report on the development of an imaging device that employs a color-coded aperture and a time-of-flight sensor to measure spectral+depth information using a single compressive snapshot.

**JTu5E • 50th Anniversary
of Introduction to Fourier
Optics by Joseph Goodman II—
Continued**

JTu5E.3 • 17:30 **Invited**

Fourier Optics in the Classroom, Masud Mansuripur¹; ¹College of Optical Sciences, Univ. of Arizona, USA. Borrowing methods and formulas from Prof. Goodman's classic *Introduction to Fourier Optics* textbook, I have developed a software package that has been used in both industrial research and classroom teaching. In this presentation, I will show a few optical system simulations that I have used over the past 30 years to convey the power and the beauty of *Fourier Optics* to our students at the Univ. of Arizona's College of Optical Sciences.

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and Applications

Mandarin

Application of Lasers for Sensing & Free
Space Communication

Tangerine

Propagation Through and Characterization
of Atmospheric and Oceanic Phenomena

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DTu5F • Computer-Generated Holograms—Continued

DTu5F.3 • 17:15

Occlusion culling techniques for layer-based computer-generated holography algorithms, Athanasia Symeonidou^{1,2}, Peter Schelkens^{1,2}, ¹Vrije Universiteit Brussel - ETRO/PL9, Belgium; ²imec, Belgium. Three occlusion processing techniques for computer-generated holography are proposed to support layer-based methods of acquiring holograms from point clouds. The techniques use Gaussian masks and masks generated by dilation per point or per layer.

DTu5F.4 • 17:30

3-D computer-generated hologram with Fourier plane segmentation, Hao Zhang¹, Liangcai Cao¹, Guofan Jin¹, ¹Tsinghua Univ., China. 3-D computer-generated hologram (CGH) is calculated by Fourier plane segmentation with shading and geometric information from multiple parallel projections. The algorithm can reconstruct photorealistic 3-D images with accurate depth information.

DTu5F.5 • 17:45

Dynamic Implementation of Computer-Generated Volume Holograms, Haiyan Wang¹, Rafael Piastun¹, ¹Univ. of Colorado Boulder, USA. We design computer-generated volume holograms and implement on a single spatial light modulator with a folded imaging system. This approach is dynamic, compact, and enhances device performance in terms of diffraction efficiency and multiplexing capacity.

3Tu5G • 360-degree Display and Perception—Continued

3Tu5G.3 • 17:30

Focusing in Depth: Post-Task Accommodation Shifts After Sustained Near Work with Volumetric Multi-Planar Display, Karola Panke¹, Vita Stokmane¹, Tatjana Pladere¹, Aiga Svede¹, Gunta Krumina¹, ¹Dept. of Optometry and Vision Science, Faculty of Physics and Mathematics, Univ. of Latvia, Latvia. Post-task refraction shifts were evaluated with eccentric photorefractive technique to better understand response of visual system and eye accommodation to sustained near work with 3D image formed by volumetric display.

3Tu5G.4 • 17:45

Looking in Depth: Visual Distance Perception of Stimuli on Volumetric Multi-Planar Display, Tatjana Pladere¹, Vita Konosonoka¹, Karola Panke¹, Gunta Krumina¹, ¹Univ. of Latvia, Latvia. Ability to distinguish relative location of visual stimuli on a multi-planar display was evaluated within psychophysical experiment in order to figure out the impact of physical distance between stimuli across depth of volumetric data.

STu5H • Quantum Protocols II—Continued

STu5H.3 • 17:30 Invited

Noise-resistant Entanglement-based Quantum Communication, Mehul Malik^{1,2}, ¹Inst. of Photonic and Quantum Sciences, Heriot-Watt Univ., UK; ²Inst. for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Austria. Enabled by the natural noise-resilience offered by high-dimensional quantum states of light, we demonstrate the distribution and certification of entanglement under extreme noise conditions corresponding to large amounts of loss or background counts.

PTu5I • Propagation in Scattering Media—Continued

PTu5I.3 • 17:15

Underwater Imaging Using Time-gated Holography and Coherent Multi-frame Processing, Dennis F. Gardner¹, Andrey Kanaev¹, Abbie T. Watnik¹, Christopher Metzler², Peter Judd¹, Paul Lebow¹, Kyle Novak³, James Lindle¹, ¹US Naval Research Lab, USA; ²Rice Univ., USA; ³Tekla Research, USA. We demonstrate an approach to imaging through extended dynamic scattering media that utilizes coherent processing of time-gated holograms. Advantages of the developed system over equivalent gated imager are revealed.

PTu5I.4 • 17:30

Phase Screens of Optical Turbulence Generated by Means of Direct Numerical Simulation of First Principles of Fluid Mechanics, Andreas Muschinski¹, Stephen M. de Bruyn Kops², ¹NorthWest Research Associates, USA; ²Dept. of Mechanical and Industrial Engineering, Univ. of Massachusetts Amherst, USA. Split-step Fourier-Fresnel algorithms based on phase screens are powerful tools to computationally simulate optical propagation through atmospheric and oceanic turbulence. Usually, phase screens are generated by means of idealized turbulence models. Here we present and discuss phase screens resulting from direct numerical simulation of the Navier-Stokes equations and the scalar transport equation.

Sunset/Fleming

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**ATu5A • Bridging Two Worlds -
Academics and Industry—
Continued**

**JTu5B • Microscopy & Imaging
(IS/AO)—Continued**

JTu5B.6 • 18:00

Modal aberration correction in confocal microscope with CCD camera detection, Pieter Smid¹, Chung See¹, Amanda J. Wright¹; ¹Univ. of Nottingham, UK. We present a confocal microscope with integrated adaptive optics and a CCD camera as a variable pinhole and detector. Aberration correction using a modal routine combined with a ray-tracing pre-correction will be discussed.

JTu5B.7 • 18:15

Matrix approach of optical coherence tomography for in-depth imaging of biological tissues, Victor Barolle¹, Amaury Badon¹, Laura Cobus¹, Kristina Irsch², Claude A. Boccara¹, Mathias Fink¹, Alexandre Aubry¹; ¹Institut Langevin, France; ²Institut de la Vision, France. We report on a reflection matrix approach of optical imaging that allows to overcome aberration and multiple scattering issues in microscopy. This allows an in-depth diffraction-limited imaging of biological media over a wide field-of-view.

**LTu5C • Atmospheric &
Environmental Monitoring II—
Continued**

LTu5C.6 • 18:00

Standoff Detection of Hazardous Chemicals using a Longwave Infrared Parametric Source, Julie Armougom¹, Jean-Michel Melkonian¹, Myriam Raybaut¹, Jean-Baptiste Dherbecourt¹, Antoine Godard¹, Nicolas Cezard¹, Riaan Coetzee², Valdas Pašiškevičius², Jirí Kadlčák³; ¹Onera, The French Aerospace Lab, France; ²Dept. of Applied Physics, Royal Inst. of Technology (KTH), Sweden; ³CBRN Protection Division, Military Research Inst. (VUV), Czechia. We report on a new longwave infrared optical parametric source, and its implementation for long range or medium range standoff detection of gaseous chemical warfare agents.

LTu5C.7 • 18:15

Highly Sensitive H₂S Detection for SF₆ Decomposition Based on Photoacoustic Spectroscopy, Lei Dong¹, Xukun Yin¹, Hongpeng Wu¹, Frank Tittel²; ¹Shanxi Univ., China; ²Rice Univ., USA. A ppb-level hydrogen sulfide (H₂S) gas sensor for sulfur hexafluoride (SF₆) decomposition analysis was developed using photoacoustic spectroscopy technique and a watt-level excitation laser source. A minimum detection limit of 109 ppb was achieved.

**CTu5D • Compressive Sensing 2:
Spectral Imaging—Continued**

CTu5D.7 • 18:00

Spectral zooming in SSCSI Compressive Spectral Imagers, Edgar E. Salazar¹, Alejandro Parada¹, Gonzalo R. Arce¹; ¹Univ. of Delaware, USA. The dependency of the number of resolvable bands on the coded aperture position is proved for the SSCSI. This allows a zooming operation over the spectral dimension of the datacube.

CTu5D.8 • 18:15

Compressive Photon-Sieve Spectral Imaging, Oguzhan Fatih Kar¹, Ulas Kamaci², Fatih C. Akyon³, Figen S. Oktem¹; ¹Middle East Technical Univ., Turkey; ²Univ. of Illinois at Urbana-Champaign, Turkey; ³Bilkent Univ., Turkey. We develop a new compressive spectral imaging modality that utilizes a coded aperture and a photon-sieve for dispersion. The 3D spectral data cube is successfully reconstructed with as little as two shots using sparse recovery.

**JTu5E • 50th Anniversary
of Introduction to Fourier
Optics by Joseph Goodman II—
Continued**

JTu5E.4 • 18:00 **Invited**

A review of the wonderful discussion of Holography by Professor Goodman in his book: *The Introduction to Fourier Optics*, Raymond Kostuk¹; ¹Univ. of Arizona, USA. In this presentation a summary is given of the different areas of holography that Professor Goodman has so clearly presented in his book: *Introduction to Fourier Optics*. These include the spatial frequency analysis of the Leith-Upatnieks hologram, volume holography, and the detour-phase method of computer generated holography. The presentation concludes with an overview of some recent applications of holography in medical imaging and solar energy conversion processes.

18:30–19:30 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman Reception, Orange/Lemon/Lime

19:00–21:00 Illumicon II, A secret location

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DTu5F • Computer-Generated Holograms— Continued

DTu5F.6 • 18:00

Fast Generation of Mesh Based CGH in Head-Mounted Displays using Foveated Rendering Technique, Yeon-Gyeong Ju¹, Jae-Hyeung Park¹; ¹Inha Univ., South Korea. In this paper, we propose a method to generate mesh-based computer-generated-hologram (CGH) rapidly using foveated rendering technique. Mesh-based CGH is one of the CGH techniques which use computer graphical information represented by polygon mesh model. Foveated rendering is a technique used in head-mounted displays (HMDs) to reduce the computational load by reducing the image resolution in peripheral area.

DTu5F.7 • 18:15

Computer generated holograms for single-beam dynamic optical traps, Jose A. Rodrigo¹, Mercedes Angulo¹, Tatiana Alieva¹; ¹Complutense Univ. of Madrid, Spain. We discuss the current advances in the holographic creation of single-beam laser traps allowing programmable optical transport of micro/nano-particles along arbitrary trajectories. The holographic approach and different optical transport experiments are analyzed.

3Tu5G • 360-degree Display and Perception—Continued

3Tu5G.5 • 18:00

Photo-based Multi-perspective Image Rendering for Tabletop Light-field 3-D Displays, Shunsuke Yoshida¹; ¹National Inst Information & Comm Tech, Japan. An image-based method of rendering multi-perspective images for tabletop light-field 3-D displays is proposed. Whereas conventional methods require 3-D polygon models, our method synthesizes them directly from photographs and ordinary computer-generated images.

3Tu5G.6 • 18:15

Design for 360-degree 3D Light-field Camera and Display, Ali O. YONTEM¹, Daping Chu¹; ¹Univ. of Cambridge, UK. A 360-degree 3D light-field acquisition and display system is proposed. Unlike conventional setups, recording and displaying rectangular volumes, proposed configuration captures and displays a cylindrical volume. Application of display stage for head-up displays is discussed.

STu5H • Quantum Protocols II—Continued

STu5H.4 • 18:00 **Invited**

Machine Learning for Adaptive Quantum Metrology, Barry C. Sanders¹, Pantita Palittapongarnpim¹, Seyed Shakib Vedaie¹; ¹Univ. of Calgary, Canada. We develop a framework for relating adaptive optical quantum-enhanced metrology, quantum control and reinforcement learning together, and we use these connections to use reinforcement learning methods for determining policies that beat the standard quantum limit.

PTu5I • Propagation in Scattering Media— Continued

18:30–19:30 50th Anniversary of Introduction to Fourier Optics by Joseph Goodman Reception, Orange/Lemon/Lime

19:00–21:00 Illumicon II, A secret location

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

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Cedar/Marathon

Mathematics in Imaging

Orange/Lemon

Computational Optical Sensing and Imaging

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07:30–18:30 Registration, Palms Foyer

Citron

08:00–09:00

JW1A • Plenary Session III

JW1A.1 • 08:00 **Plenary**

Exoplanet Imaging: From Precision Optics to Precision Measurements, Laurent Pueyo, *Space Telescope Science Institute, USA*. During this plenary talk Laurent will present recent observational results in exoplanet imaging and discuss prospects for similar experiments on NASA missions such as the upcoming James Webb Space Telescope and the currently studied The Large UV/Optical/IR Surveyor.

09:00–10:00 Coffee Break with Exhibitors, Palms Foyer

10:00–12:00

AW2A • You Down With OCT (Yeah You Know Me)

Presider: Thomas Haslett; Avo Photonics Inc, Canada

10:00–12:00

IW2B • Computer Vision & Image Processing

Presider: Kenneth Barnard; US Air Force Research Lab, USA

10:00–12:00

LW2C • Velocimetry, Films & Fundamentals

Presider: Steven Wagner; Technische Universität Darmstadt, Germany

10:00–11:45

MW2D • Sparsity Based Priors

Presider: Ulugbek Kamilov; Washington Univ. in St. Louis, USA

10:00–12:00

CW2E • Computational Microscopy

Presider: Antony Chan; California Institute of Technology, USA

AW2A.1 • 10:00 **Invited**

On-bench validations of tunable lens based multifocal visual simulations, Vyas Akondi¹, Lucie Sawides², Yassine Marrakchi², Enrique Gamba², Xoana Barcala^{1,2}, Susana Marcos¹, Carlos Dorronsoro¹; ¹Consejo Sup Investigaciones Científicas, Spain; ²Eyes Vision SL, Spain. SimVis is a tunable lens based see-through portable binocular visual simulator of multifocal corrections. It is shown using fast focimetry that accurate SimVis multifocal simulations are possible with iterative evaluation of the theoretical SimVis temporal profile and the correction of the dynamic characteristics of the tunable lens.

IW2B.1 • 10:00 **Invited**

Incoherent Super-resolution Imaging, Jane N. Sprigg¹; ¹Tarsier Optics, USA. I discuss the benefits and limitations of a second-order high resolution incoherent imaging method produced by correlating the intensity fluctuations from the average measured by two spatially separated detectors. This method isolates a well-resolved second-order image from the unresolved first-order or classical image and achieves a resolution improvement of approximately a factor of 4. This means for a given resolution the lens size could be reduced by a factor of 4, which is useful in fields where reducing lens size or weight is important.

LW2C.1 • 10:00 **Invited**

Single-shot vibrational energy distributions of a microscale detonation using hybrid fs/ps CARS, Chloe E. Dedic¹, James Michael², Terrence Meyer³; ¹Mechanical and Aerospace Engineering, Univ. of Virginia, USA; ²Dept. of Mechanical Engineering, Iowa State Univ., USA; ³School of Mechanical Engineering, Purdue Univ., USA. Single-shot O₂ and N₂ vibrational energy distributions behind gaseous detonations are studied using hybrid fs/ps CARS. Differences in measured vibrational temperature and Chapman-Jouguet predictions are discussed using detonation theory and nonequilibrium kinetics.

MW2D.1 • 10:00 **Invited**

L2-L0 optimization for single molecule localization microscopy, Arne Bechensteen¹, Simone Rebegoldi³, Gilles Aubert², Laure Blanc-Féraud¹; ¹Université Côte d'Azur, CNRS, INRIA, Laboratoire I3S, France; ²Université Côte d'Azur, UNS, Laboratoire Dleudonné, France; ³Dipartimento di Matematica e Informatica, Università degli studi di Ferrara, Italy. We focus on the problem of minimizing a least-squares loss function under a k-sparse constraint. We investigate the continuous relaxation approach as well as optimization algorithms to apply on Single Molecule Localization Microscopy.

CW2E.1 • 10:00 **Invited**

Redesigning microscopes for improved image classification, Roarke Horstmeyer¹, Richard Chen², Mark Harfouche³, Alex K. Muthumbi⁴; ¹Biomedical Engineering, Duke Univ., USA; ²Y Combinator Research, USA; ³California Inst. of Technology, USA; ⁴Graduate School in Advanced Optical Technologies, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany. We use convolutional neural networks to optimize the layout of a microscope and improve image classification accuracies by up to 10%. The method is applied with low-resolution, wide field-of-view systems for high throughput.

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07:30–18:30 Registration, Palms Foyer

Citron

08:00–09:00

JW1A • Plenary Session III

JW1A.1 • 08:00 **Plenary**

Exoplanet Imaging: From Precision Optics to Precision Measurements, Laurent Pueyo, *Space Telescope Science Institute, USA*. During this plenary talk Laurent will present recent observational results in exoplanet imaging and discuss prospects for similar experiments on NASA missions such as the upcoming James Webb Space Telescope and the currently studied The Large UV/Optical/IR Surveyor.

09:00–10:00 Coffee Break with Exhibitors, Palms Foyer

10:00–12:00

DW2F • Deep Learning in DH

Presider: Laura Waller; University of California Berkeley, USA

DW2F.1 • 10:00 **Keynote**

Machine Learning Enabled Computational Imaging and Sensing for Point-of-Care Medicine and Global Health, Aydogan Ozcan¹; ¹Univ. of California Los Angeles, USA. We provide an overview of our recent work on the use of machine learning, including e.g., deep neural networks, in advancing computational imaging and sensing systems, targeting various global health and point-of-care medicine related applications.

10:30–12:00

3W2G • Measurement II

Presider: Hong Hua; Univ. of Arizona, USA

3W2G.1 • 10:00
Withdrawn

10:00–12:00

SW2H • Quantum Protocols III

Presider: Walter Buell; The Aerospace Corporation, USA and Edward Watson; Univ. of Dayton, USA

SW2H.1 • 10:00 **Invited**

Ultrafast measurement of energy-time entangled states, Kevin Resch¹; ¹Univ. of Waterloo, Canada. We implement fast optical gating to directly measure the temporal correlations in energy-time entangled photon pairs with sub-picosecond resolution. We apply this technique to ultrafast two-photon interferometry and nonlocal dispersion cancellation.

10:00–12:00

PW2I • Atmospheric Propagation

Presider: Sukanta Basu; Delft University of Technology, Netherlands

PW2I.1 • 10:00 **Invited**

My Journey from Radar Jamming to Coherence Theory, Joseph W. Goodman¹; ¹Stanford Univ., USA. My graduate research was concerned with radar detection, radar countermeasures, passive locating systems, and countermeasures to passive locating system. After I learned some statistical optics, I realized that predicting the effectiveness of a particular countermeasure to passive locating systems could be accomplished rather easily using the Van Cittert-Zernike theorem. This insight will be explained in this talk.

10:00–12:00

OW2J • Wavefront/Beam Control & Sensing I

Presider: Jie Qiao; Rochester Inst. of Technology, USA

OW2J.1 • 10:00 **Invited**

X-Ray Bimorph Deformable Mirrors: Capabilities and Perspectives, Luca Peverini¹; ¹R&D, Thales SESO S.A.S., France. The principle and performance of a set of XBDM for hard X-rays are reviewed. The examples presented will includes variable focus mirror systems, KB-systems, multilayer coated and nanofocusing mirror optics with slope errors below 200nrad.

Wednesday, 27 June

Sunset/Fleming

Applied Industrial Optics

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Imaging Systems and Applications

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AW2A • You Down With OCT (Yeah You Know Me)—Continued

AW2A.2 • 10:30 Invited
Clinical Sensorless Adaptive Optics OCT and Angiography, Yifan Jian¹; ¹Simon Fraser Univ., Canada. We will present our recent progress on Sensorless AO-OCT (SAO-OCT) system development, and several key technology advances will be discussed in detail. Case reports on patients with various retinal pathologies will be presented.

IW2B • Computer Vision & Image processing—Continued

IW2B.2 • 10:30
Measurement of Modulation Transfer Function using Digital Micromirror Devices, Anton Travinsky¹; ¹Rochester Inst. of Technology, USA. We present and discuss a digital micromirror device-based method for measurement of the modulation transfer function. Advantages of this method include remote performance evaluation, arbitrary re-configurable target, and ability to conduct single-shot measurements.

IW2B.3 • 10:45
Bayer and demosaicking effect for imaging the stress field in digital photoelasticity, Juan C. Briñez de León¹, Hermes A. Fandiño Toro^{1,2}, Alejandro Restrepo Martínez¹, John W. Branch Bedoya¹; ¹Universidad Nacional de Colombia, Colombia; ²Sistemas de información, ITM, Colombia. Imaging the stress field is a complex process performed, and nowadays simulated, in digital photoelasticity. In these simulations we demonstrate that the Bayer and demosaicking effect must be considered because they introduce different errors.

LW2C • Velocimetry, Films & Fundamentals—Continued

LW2C.2 • 10:30
Performant Multispectral LIF System with Spectral and Temporal Features for CBE Detection, Frank Duschek¹, Lea Fellner¹, Florian Gebert¹, Marian Kraus¹; ¹German Aerospace Center, Germany. The classification of CBE hazards is commonly not best performing if based on laser-induced fluorescence. Improving the technology by recording spectral and temporal fluorescence emission a significant gain of information can be achieved. Machine learning algorithms show a major contribution of temporal fluorescence data to the classification of biological agents.

LW2C.3 • 10:45
Water Film Thickness Imaging Based on Time-Multiplexed Near-Infrared Absorption, Marc Lubnow¹, Thomas Dreier¹, Christof Schulz¹; ¹Univ. of Duisburg-Essen IVG, Germany. We demonstrate the imaging of water film thickness measurements at constant temperature by exploiting absorbance ratios of near-infrared (NIR) radiation at two different wavelengths in the water absorption spectrum around 1400 nm with light delivered by diode lasers and signal registered by a fast framing InGaAs focal plane array camera. Measurements are performed in reflection mode from opaque film support surfaces.

MW2D • Sparsity Based Priors—Continued

MW2D.2 • 10:30
Sparse Phase Retrieval Algorithm via Smoothing Function in Compressive Optical Imaging, Samuel E. Pinilla¹, Jorge Bacca¹, Daniel Molina¹, Ariolfo Camacho¹, Henry Arguello¹; ¹Universidad Industrial de Santander, Colombia. This paper proposes an algorithm to solve the phase retrieval problem in optical imaging in two stages. First, we introduce an initialization to estimate the support of the sparse representation Θ in some sparse basis Ψ of an image x . Second, we solve a smoothing optimization problem to reconstruct x . Simulations show that the proposed algorithm requires less number of measurements compared with existing methods.

MW2D.3 • 10:45
Super-Resolution Phase Retrieval Algorithm using a Smoothing Function, Jorge L. Bacca¹, Samuel E. Pinilla¹, Daniel Molina¹, Ariolfo Camacho¹, Henry Arguello¹; ¹Universidad Industrial de Santander, Colombia. This paper presents a super-resolution phase retrieval algorithm which solves a smoothing optimization problem, allowing to obtain a high resolution signal from low-resolution measurements.

CW2E • Computational Microscopy—Continued

CW2E.2 • 10:30
Field-varying aberration recovery in EUV microscopy using mask roughness, Gautam K. Gunjala¹, Antoine Wojdyła², Aamod Shanker¹, Stuart Sherwin¹, Markus Benk², Kenneth Goldberg², Patrick Naulleau², Laura Waller¹; ¹Univ. of California, Berkeley, USA; ²Lawrence Berkeley National Lab, USA. We derive and solve a simplified, self-calibrated inverse problem to characterize the field-dependent aberrations of an EUV synchrotron-based full-field microscope, using images of the surface roughness of an EUV photomask under several angles of illumination. We demonstrate diffraction-limited imaging performance at the center of its field-of-view.

CW2E.3 • 10:45
Computational Cannula Microscopy: Utilizing a Simple Glass Needle for Imaging, Jacqueline Cooke¹, Gunhun Kim¹, Jason Shepherd³, Naveen Nagarajan², Elissa Pastuszyn³, Kyle R. Jenks³, Mario Capecchi², Rajesh Menon¹; ¹Electrical and Computer Engineering, Univ. of Utah, USA; ²Human Genetics, Univ. of Utah, USA; ³Neurobiology and Anatomy, Univ. of Utah, USA. Existing brain imaging sensors are either limited in their depth, resolution, and/or inflict trauma. To improve on these limitations, we demonstrate fluorescent microscopy through an optical cannula for deep tissue imaging.

Citron

Digital Holography &
3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and
Applications

Mandarin

Application of Lasers for Sensing &
Free Space Communication

Tangerine

Propagation Through and
Characterization of Atmospheric
and Oceanic Phenomena

Lime

Adaptive Optics: Methods,
Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DW2F • Deep Learning in DH— Continued

DW2F.2 • 10:45

In-line Hologram Reconstruction with Deep Learning, Hao Wang^{1,2}, Meng Lyu^{1,2}, Ni Chen¹, Guohai Situ¹; ¹*Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China*; ²*Univ. of Chinese Academy of Sciences, China*. Deep neural network (DNN) has been applied in many fields. Here, we use DNN to separate interference terms in in-line hologram and reconstruct the pure phase object. The experiment result verifies our method's feasibility.

3W2G • Measurement II— Continued

3W2G.2 • 10:30

Micro Resolution Time-of-Flight Imaging, Fengqiang Li¹, Florian Willomitzer¹, Prasanna V. Rangarajan², Andreas Velten³, Mohit Gupta³, Oliver S. Cossairt¹; ¹*Northwestern Univ., USA*; ²*Southern Methodist Univ., USA*; ³*Univ. of Wisconsin Madison, USA*. We propose a time-of-flight imaging technique with modulation frequencies as high as 1 THz using optical superheterodyne interferometry. Our proposed system provides great flexibility in imaging range and resolution.

3W2G.3 • 10:45

3D Compressive LIDAR Imaging Using Multiscale-Ordered Hadamard Basis, Vladislav Kravets¹, Adrian Stern¹; ¹*Electro-Optical Engineering, Ben Gurion Univ. of the Negev, Israel*. We introduce an application of multiscale-ordering of the Hadamard basis for compressive LIDAR acquisition on synthetic 3D images. Improvement in quality of the reconstruction and other advantages over conventional compressed sensing, will be presented.

SW2H • Quantum Protocols III— Continued

SW2H.2 • 10:30 **Invited**

Quantum-Secured Communication at Gbps Rates, Franco N. Wong¹, Zheshen Zhang¹, Changchen Chen¹, Quntao Zhuang¹, Jane E. Heyes¹, Jeffrey H. Shapiro¹; ¹*MIT, USA*. We achieve Gbps secret-key rates in 10-dB-loss fiber channel quantum key distribution based on a two-way protocol with multimode encoding, decoding by collective multimode homodyne reception, and coincidence-based channel monitoring to prevent frequency-domain collective attacks.

PW2I • Atmospheric Propagation—Continued

PW2I.2 • 10:30

Monostatic LIDAR in Non-Classic Atmospheric Turbulence, Olga Korotkova¹, Jia Li¹, Gordon Martinez-Piedra^{1,2}; ¹*Univ. of Miami, USA*; ²*Physics, Eton College, UK*. Results of experiments involving He-Ne laser beam propagation through monostatic channel with retro-reflector, in which non-classic (inhomogeneous, anisotropic) air turbulence is generated in several ways. Enhanced Back-Scatter of intensity statistics is investigated.

PW2I.3 • 10:45 **Invited**

Improving Atmospheric Turbulence Parameterization using Numerical Weather Prediction and Lidars, Stephen Hammel¹; ¹*SPAWAR Systems Center Pacific, USA*. The atmosphere from earth's surface up through the boundary layer top provides a challenging optical propagation environment. I discuss a project to predict optical system performance assessment by using numerical weather prediction (NWP) and lidars.

OW2J • Wavefront/Beam Control & Sensing I—Continued

OW2J.2 • 10:30

Developing Bimorph Mirrors into Rapidly Deformable Active Optics for Synchrotron X-ray Beamlines, Simon G. Alcock¹, Ioana Nistea¹, John Sutter¹, Robin L. Owen¹, Daniel Axford¹, Andrew Foster¹, Kawal Sawhney¹, Riccardo Signorato²; ¹*Diamond Light Source Ltd, UK*; ²*CINEL Strumenti Scientifici s.r.l., Italy*. Recent technical improvements have significantly reduced the response time of deformable piezoelectric bimorph mirrors for synchrotron X-ray beamlines. Major changes to the mirror's curvature are now possible in seconds without loss of necessary nanometer precision.

OW2J.3 • 10:45

Wavefront shaping method to focus light through a mouse skull, Nektarios Koukourakis¹, Moritz Kreysing², Jürgen Czarske¹; ¹*TU Dresden, Germany*; ²*Max-Planck Inst. of Molecular Cell Biology and Genetics, Germany*. We focus through 400 μ m thick mouse skull using digital optical phase conjugation and discuss the memory effect and approaches to use backscattered light to determine the descrambling phase mask.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

Orange/Lemon

Computational Optical Sensing and Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AW2A • You Down With OCT (Yeah You Know Me)—Continued

AW2A.3 • 11:00

OCT-Based Wavefront Shaping: Towards OCT Image Enhancement and Depth-Selective Focusing, Jonas P. Kannigieser¹, Maik Rahlves¹, Bernhard Roth¹; ¹Hannoversches Zentrum für Optische Technologien, Gottfried Wilhelm Leibniz Universität Hannover, Germany. We demonstrate the implementation of wavefront shaping in Optical Coherence Tomography (OCT). This combination opens up new ways for OCT signal enhancement as well as for non-invasive focusing of light inside scattering media.

AW2A.4 • 11:15 **Invited**

Development of a low cost, portable Optical Coherence Tomography system, Adam Wax¹; ¹Lumedica, Inc., USA. OCT is a widely used biomedical imaging tool, primarily to diagnose and stage retinal diseases. To increase access, we developed a portable, low-cost OCT system with comparable imaging performance to commercially available systems.

DEMO

Adam Wax will present the Lumedica low cost OCT system, demonstrating the product features and capabilities and conduct a few imaging examples.

IW2B • Computer Vision & Image processing—Continued

IW2B.4 • 11:00 **Invited**

Toward Miniature Computer Vision Sensors, Sanjeev Koppal¹; ¹Univ. of Florida, USA. Biological vision performs amazing visual tasks with negligible power consumption. Despite the fantastic strides in computer vision in recent years, delivering such high-performance and real-time capability, within tiny power budgets, is still a distant dream. This talk is about our work in solving the core problems that will enable computer vision on miniature platforms.

LW2C • Velocimetry, Films & Fundamentals—Continued

LW2C.4 • 11:00 **Invited**

Development of unseeded Molecular Tagging Velocimetry for high-Reynolds number transonic wind tunnels, Paul M. Danehy¹, Ross Burns²; ¹NASA Langley Research Center, USA; ²National Inst. of Aerospace, USA. This talk describes a molecular tagging velocimetry technique based on femtosecond lasers which has been developed for cryogenic transonic wind tunnels, which simulate high-Reynolds number aircraft flight in ground-based test facilities.

MW2D • Sparsity Based Priors—Continued

MW2D.4 • 11:00 **Invited**

l1-Analysis Minimization and Generalized (Co-)Sparsity: When Does Recovery Succeed?, Maximilian März¹, Gitta Kutyniok¹, Martin Genzel¹; ¹TU Berlin, Germany. Frame based regularization methods of inverse problems are particularly effective in their analysis formulation. We will present a novel compressed sensing bound on the sample complexity of the l1-analysis basis pursuit.

CW2E • Computational Microscopy—Continued

CW2E.4 • 11:00

Integral Refractive Index Imaging of Flowing Cell Nuclei, Gili Dardikman¹, Yoav Nuygate¹, Itay Barnea¹, Nir Turko¹, Gyanendra Singh¹, Barham Javidi², Natan T. Shaked¹; ¹Dept. of Biomedical Engineering, Tel Aviv Univ., Israel; ²Dept. of Electrical and Computer Engineering, Univ. of Connecticut, USA. We review our new imaging technique for quantitatively measuring the integral (thickness-average) refractive index of the nuclei of live biological cells during flow, combining quantitative phase microscopy with simultaneous 2-D fluorescence microscopy for nucleus localization.

CW2E.5 • 11:15

Compressive hyperspectral imaging for snapshot multi-channel fluorescence microscopy, Jijun He¹, Jiamin Wu¹, Zhi Lu¹, Qionghai Dai¹; ¹Tsinghua Univ., PRC, China, China. We present a snapshot multi-channel fluorescence microscopy by compressive hyperspectral imaging, especially for the fluorescence with an overlap in spectrum. Our method creates a spatial-spectral coded image, and retrieves the multi-channel data with over-complete dictionary.

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DW2F • Deep Learning in DH—Continued

DW2F.3 • 11:00

Classification of Digital Holograms with Deep Learning and Hand-Crafted Features, Tomi Pitkaaho¹, Aki Manninen², Thomas J. Naughton¹; ¹Maynooth Univ., Ireland; ²Biocenter Oulu, Univ. of Oulu, Finland. Digital holographic microscopy allows a single-shot label-free imaging of living microscopic objects using a low intensity laser. Using reconstructed quantitative phase as an input to a convolutional neural network, detection of tumorigenic samples is possible.

DW2F.4 • 11:15

3D Optical Diffraction Tomography Using Deep Learning, George Nehmetallah¹, Thanh Nguyen¹, Vy Bui¹; ¹Catholic Univ. of America, USA. We developed a 3D deep convolutional neural network (3D-DCNN) to perform 3D diffraction optical tomography. We experimentally demonstrate the ability of a 3D-DCNN to reconstruct the 3D index of refraction distribution of a phantom dataset.

3W2G • Measurement II—Continued

3W2G.4 • 11:00

Classifying Transverse Motion in Time-of-Flight Range Imaging, Lee Streeter¹, Michael Cree¹; ¹Univ. of Waikato, New Zealand. Classification of step motion in time-of-flight imaging using the stochastic oscillator and autocorrelation is proposed. Machine learning algorithms correctly identify the step location in 65–75% of trials, with apparent good noise robustness.

3W2G.5 • 11:15

Refractive Diffusers for Efficient Time-of-flight Illumination, Tasso R. Sales¹, Donald J. Schertler¹, Amber Betzold¹, Stephen Chakmakjian¹, G. M. Morris¹, Jim Northup¹; ¹RPC Photonics Inc, USA. We discuss the use of Engineered Diffusers™ for efficient illumination of scenes for time of flight and 3D sensing applications. These diffusers can provide controlled, inverse-cosine intensity for uniform illumination at the scene or sensor.

SW2H • Quantum Protocols III—Continued

SW2H.3 • 11:00 Invited

Structured Waves: From Matter to Light, Dmitry A. Pushin¹, Dusan Sarenac¹, Joachim Nsofini¹, Ian Hincks¹, Paulo Miguel¹, Michael G. Huber², Benjamin Heacock³, Muhammad Arif², Charles W. Clark^{2,4}, David G. Cory^{1,5}; ¹Univ. of Waterloo, Canada; ²National Inst. of Standards and Technology, USA; ³North Carolina State Univ., USA; ⁴Joint Quantum Inst., USA; ⁵Perimeter Inst. for Theoretical Physics, Canada. Neutrons are important probes of matter and quantum physics. They are particularly powerful at characterizing magnetic structures. In order to extend the applications of neutron physics as a quantum sensors we have developed methods based on Quantum Information Processing for preparing structured waves of neutrons. I will show how to prepare and characterize neutron beams with specific orbital and spin-orbit structure based on neutron interferometry and will show how we can apply these methods to other type of probes such as light.

PW2I • Atmospheric Propagation—Continued

PW2I.4 • 11:15

Modulation of Optical Turbulence by Atmospheric Aerosols: Influence of Vertical Distribution and Residence Time, Anand N. Sarma¹, Satheesh S K¹, Krishna Moorthy K¹; ¹Indian Inst. of Science, India. We report how atmospheric aerosols modulate optical turbulence by varying the refractive index structure parameter (C_n^2). As the residence time and concentration of aerosols increases, the modulation would transform from weak to strong turbulence regime.

OW2J • Wavefront/Beam Control & Sensing I—Continued

OW2J.4 • 11:00

Scene-based Shack-Hartmann Wavefront Sensor for Light-Sheet Microscopy, Kee-lan Lawrence¹, Yang Liu¹, Rebecca Ball², Ariel VanLeuven², James D. Lauderale², Peter Kner¹; ¹College of Engineering, Univ. of Georgia, USA; ²Dept. of Cellular Biology, Univ. of Georgia, USA. Light Sheet Microscopy is well suited for imaging model organisms and tissue sections that are hundreds of microns thick. Adaptive Optics is needed to correct aberrations in these samples. Here we describe our design of a scene based Shack Hartmann Wavefront Sensor for Light Sheet Microscopy.

OW2J.5 • 11:15

Dynamic Adaptive Optical Image Correction for Velocimetry, Lars Buettner¹, Martin Teich¹, Hannes Radner¹, Jürgen Czarske¹; ¹Technische Universität Dresden, Germany. Imaging, correlation-based velocity measurements through time-varying optical distortions are presented for application in microfluidics. Using a deformable membrane mirror and an iterative FPGA-based optimization process, aberrations up to several 100 Hz can be corrected.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

Orange/Lemon

Computational Optical Sensing and Imaging

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AW2A • You Down With OCT (Yeah You Know Me)—Continued

IW2B • Computer Vision & Image processing—Continued

IW2B.5 • 11:30
Illumination Pattern Estimation for Multiple Exposures Extraction in a Snapshot Imaging Technique, Karolina Dorozynska¹, Elias Kristensson¹; ¹*Lunds Universitet, Sweden*. We present an improvement to the snapshot imaging technique, FRAME, where the phase information is included in the illumination pattern estimation for image extraction. This can potentially improve the image storage capacity and resolution.

IW2B.6 • 11:45
Data-Driven Non-Line-of-Sight Imaging With A Traditional Camera, Matthew Tancik¹, Tristan Swedish¹, Guy Satat¹, Ramesh Raskar¹; ¹*MIT, USA*. Non-line-of-sight (NLOS) imaging has recently been demonstrated using traditional cameras. Here we present a data-driven technique for NLOS imaging. We experimentally analyze the role of scene geometry and clutter on reconstruction quality.

LW2C • Velocimetry, Films & Fundamentals—Continued

LW2C.5 • 11:30
Determination of O₂-O₂ S-branch Raman linewidths using time-resolved picosecond pure rotational coherent anti-Stokes Raman scattering, Christian Meißner^{1,2}, Jonas Hölzer^{1,2}, Thomas Seeger^{1,2}; ¹*Univ. of Siegen, Germany*; ²*Center for Sensorsystems (ZESS), Germany*. The evaluation of O₂-O₂ S-branch Raman linewidths for different temperatures at ambient pressure using time-resolved picosecond dual-broadband pure rotational coherent anti-Stokes Raman scattering is presented. S-branch Raman linewidths are compared to corresponding Q-branch literature data.

LW2C.6 • 11:45
Theoretical limits of nonuniform temperature retrievals with single-beam absorption spectroscopy, Nathan Malachuk¹, Gregory B. Rieker¹; ¹*Univ. of Colorado Boulder, USA*. We assess the potential to resolve line-of-sight gas temperature along a single large-frequency-bandwidth laser beam. We describe a regularization method to recover the maximum temperature, a key combustion quantity.

MW2D • Sparsity Based Priors—Continued

MW2D.5 • 11:30
The geometry of convex regularized inverse problems, Pierre Weiss¹; ¹*Université de Toulouse, CNRS, France*. In this talk, I will present recent results regarding the geometry of solutions of inverse problems regularized by a convex regularizer.

CW2E • Computational Microscopy—Continued

CW2E.6 • 11:30
Cell imaging by phase extraction neural network (PhENN), Shuai Li¹, Ayan Sinha¹, Justin Lee¹, George Barbastathis^{1,2}; ¹*MIT, USA*; ²*Singapore-MIT Alliance for Research and Technology (SMART) Centre, Singapore*. We trained a phase extraction neural network (PhENN) using a spatial light modulator (SLM) and applied it to a wide-field microscope to reconstruct the phase profiles of cell samples.

CW2E.7 • 11:45
Quantitative Phase Maps of Live Cells Classified By Transfer Learning and Generative Adversarial Network (GAN), Moran Rubin¹, Omer Stein¹, Raja Giryes¹, Darina Roitshtain¹, Natan T. Shaked¹; ¹*Tel Aviv Univ., Israel*. We suggest a new approach for classification of label-free quantitative phase maps of live cells using only a small training set, based on a combination between generative adversarial networks (GANs) and transfer learning.

12:00–13:00 Applications of Visual Science Technical Group Networking Lunch, Salon C

12:00–13:30 Lunch on your Own

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

DW2F • Deep Learning in DH—Continued

DW2F.5 • 11:30
Compressing Macroscopic Near-field Digital Holograms With Wave Atoms, Tobias Birnbaum¹, David Blinder¹, Colas Schretter¹, Peter Schelkens¹; ¹*Virje Universiteit Brussels - ETRO-IMEC, Belgium*. Pushing digital holography into mainstream markets requires efficient compression algorithms. Using a recent technique based on wave atoms, we explore its compression performance for macroscopic near-field holograms as a function of the Fresnel number.

DW2F.6 • 11:45
A Novel Training Method for Faster R-CNN based Object Detection in Multi-modal Images, Fan Yang¹, Sheng Lu¹, Sidan Du¹, Yang Li¹; ¹*School of Electronic Science and Engineering, Nanjing Univ., China*. Conventional methods feed multi-modal images indiscriminately into model during training, introducing possible downgrading of performance. A novel stepwise method that trains different parts of multi-modal Faster R-CNN using different sub-datasets is presented, showing satisfactory results.

3W2G • Measurement II—Continued

3W2G.6 • 11:30
Pupil Function Engineered for Improved SLAM Feature Localization, Paulo E. Silveira¹; ¹*Euclid Consulting, USA*. FAST has become one of the most utilized methods for finding features in image-based SLAM. However, most algorithms assume operation with images captured by conventional imaging systems, ignoring the advantages enabled by engineered pupil functions.

3W2G.7 • 11:45
Monocular SLAM Using Probabilistic Combination of Point and Line Features, Yang Li¹, Bing Yu¹, Chao Ping Chen¹, Nizamuddin Mailto¹, Wen Bo Zhang¹, Lan Tian Mi¹; ¹*Shanghai Jiao Tong Univ., China*. We propose a monocular SLAM, in which a probabilistic combination of point and line features is adopted. Compared with point-based ORB-SLAMs, our solution is effective in improving both the accuracy and robustness under low-textured scenarios.

SW2H • Quantum Protocols III—Continued

SW2H.4 • 11:30 **Invited**
Free-Space Quantum Communication Links using Orbital-Angular-Momentum, Alan E. Willner¹; ¹*Univ. of Southern California, USA*. A photon can carry different values of orbital-angular-momentum (OAM), thereby representing a larger set of possible orthogonal states for quantum communication systems. This paper will describe issues related to such links, including data encoding and turbulence mitigation.

PW2I • Atmospheric Propagation—Continued

PW2I.5 • 11:30 **Invited**
Coherent Lidar Techniques for Atmospheric Turbulence Measurements and Imaging, Zeb W. Barber¹, Jason Dahl¹, Christopher Blaszczyk¹, Stephen Crouch², Jordan Love², Brennan Kilty², Emil Kadlec², Randy Reibel²; ¹*Spectrum Lab, Montana State Univ., USA*; ²*Blackmore Sensors and Analytics, USA*. Coherent lidar techniques by providing direct measurement of optical phase enables advanced techniques for long-range imaging, atmospheric turbulence measurements, and potentially imaging through turbulence without the use of adaptive optics.

OW2J • Wavefront/Beam Control & Sensing I—Continued

OW2J.6 • 11:30
A highly-miniaturized optofluidic refractive adaptive optics system, Kaustubh Banerjee¹, Pouya Rajaeipour¹, Çağlar Ataman¹, Hans Zappe¹; ¹*Univ. of Freiburg, Germany*. We demonstrate a novel electrostatically actuated optofluidic transmissive phase modulator for an in-line refractive adaptive optics system. The phase modulator has a best-flat of 20 nm and is able to perform corrections of Zernike polynomials up to the 4th radial order.

OW2J.7 • 11:45
Adaptive Optics for 3D Structured Illumination Fluorescence Microscopy, Mantas Zurasukas¹, Ian Dobbie², Martin J. Booth^{1,3}; ¹*Centre for Neural Circuits and Behaviour, Univ. of Oxford, UK*; ²*Micron Advanced Bio-imaging Facility, Univ. of Oxford, UK*; ³*Dept. of Engineering Science, Univ. of Oxford, UK*. We present a three-beam interference adaptive 3D SIM fluorescence microscope. Here, wavefront control for aberration correction and remote focusing is enabled by novel hybrid wavefront sensing approach that combines interferometric and image quality driven sensing.

12:00–13:00 Applications of Visual Science Technical Group Networking Lunch, Salon C

12:00–13:30 Lunch on your Own

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Mathematics in Imaging

Orange/Lemon

Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

13:30–15:30

AW3A • Animal Optics: The Facts of Light

Presider: Cushla McGoverin; Univ. of Auckland, New Zealand

AW3A.1 • 13:30

Nanoscale 3D Shape Process Monitoring Using TSOM, Ravikiran Attota¹; ¹NIST, USA. Through-focus scanning optical microscopy (TSOM) is sensitive to three-dimensional shape changes of nanoscale to microscale targets. Here we demonstrate process monitoring method of 3D targets using TSOM down to sub-nanometer.

AW3A.2 • 13:45

Investigation of Optical Signatures for Discriminating Salmon Lice from Other Species of Zooplankton, Josefine H. Nielsen^{1,2}, Jord C. Prangma², Thomas Kjørboe³, Mikkel Brydegaard^{4,5}, Christian Pedersen¹, Peter John Rodrigo¹; ¹DTU Fotonik, Technical Univ. of Denmark, Denmark; ²FaunaPhotonics ApS, Denmark; ³DTU Aqua, Technical Univ. of Denmark, Denmark; ⁴Norsk Elektro Optikk Lund AB, Sweden; ⁵Lund Laser Centre, Lund Univ., Sweden. We present a study of optical signatures of salmon lice and the ability to distinguish them from a reference zooplankton species. This forms the basis for developing an instrument for detecting salmon lice *in situ*.

13:30–15:30

CW3B • Machine Learning in Computational Sensing and Imaging I

Presider: Patrick Lull; Google, Inc., USA

CW3B.1 • 13:30 **Invited**

A Neuro-Inspired Model for Image Motion Processing, Kaiser Niknam¹, Amir Akbarian⁴, Behrad Noudoost³, Neda Nategh^{1,2}; ¹Electrical and Computer Engineering, Univ. of Utah, USA; ³Ophthalmology and Visual Sciences, Univ. of Utah, USA. This study develops a computational framework for robust image analysis in the presence of observer motion, such as a moving camera, based on the brain code of robust motion computations during eye movements.

13:30–15:30

LW3C • Techniques for Reactors, Shock Tubes & Cells

Presider: Wolfgang Meier; German Aerospace Center DLR, Germany

LW3C.1 • 13:30 **Invited**

Recent developments in time-resolved laser absorption techniques for high-temperature chemical kinetics, Subith S. Vasu¹; ¹Univ. of Central Florida, USA. Current work will focus on using shock tubes and recent absorption-based laser-based diagnostics for acquiring quantitative high-temperature species concentration time-histories and chemical kinetic reaction rates for a variety of applications in energy, propulsion, and explosions.

13:30–15:30

MW3D • Application in 3D Microscopy

Presider: Jun Ke; Beijing Inst. of Technology, China

MW3D.1 • 13:30 **Invited**

Signal Processing Methods for Cell Localization and Activity Detection from Calcium Imaging Data, Pier L. Dragotti¹; ¹EEE, Imperial College London, UK. Two-photon calcium imaging enables the study of brain activity at single-cell resolution. However, a comprehensive study of activity in even one brain area can produce terabytes of imaging data which presents a considerable signal processing challenge. In this talk, we present a flexible method for the automatic segmentation of regions of interest and for accurate calcium transient detection which leverages from recent developments in sampling theory and signal processing methods.

13:30–15:15

JW3E • Aerospace Imaging (COSI/IS)

Presider: Matthew Arnison; Canon Info. Sys. Research Australia, Australia

JW3E.1 • 13:30 **Invited**

2017 Eclipse Across America: Through the Eyes of NASA, C Alex Young¹; ¹Helio-physics Science Division, NASA Goddard Space Flight Center, USA. Dr. Young presents NASA supported science to image the Sun's corona and study Earth's atmosphere from the ground, high altitude balloons, aircraft and spacecraft during the August 21, 2017 total solar eclipse.

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Propagation Through and
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and Oceanic Phenomena

Lime

Adaptive Optics: Methods,
Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

13:30–15:30

DW3F • Multi-wavelength Digital Holography

Presider: Pablo Ruiz; Loughborough Univ., UK

13:30–15:30

3W3G • Light Field Display

Presider: Bahram Javidi; Univ. of Connecticut, USA

13:30–14:30

SW3H • Components II

Presider: Edward Watson; Univ. of Dayton, USA

13:30–15:15

PW3H • Environmental Propagation

Presider: Karin Stein; Fraunhofer IOSB, Germany

13:30–15:00

OW3J • Wavefront/Beam Control & Sensing II

Presider: Sergio Restaino; US Naval Research Lab, USA

DW3F.1 • 13:30 **Invited**

Multi-Wavelength Digital Holography for Erosion Measurements inside the ITER Tokamak, Giancarlo . Pedrini¹, Igor Alekseenko¹, Wolfgang Osten¹, Govind Jagannathan², Mark Kempenaars³, George Vayakis⁴, ¹Universität Stuttgart, Germany; ²Port Plugs and Diagnostic, ITER, France; ³ITER, France. Experimental results of remote shape measurements of objects located at a distance of more than 6 m from the detector with depth accuracies of 10 micrometers are presented. The system is planned for erosion measurements inside the ITER Tokamak reactor.

3W3G.1 • 13:30 **Invited**

3D Hand Gesture Recognition using Integral Imaging, Filiberto Pla¹, Pedro Latorre-Carmona¹, Eva Salvador-Balaguer¹, Bahram . Javidi²; ¹Institute of New Imaging Technologies, Univ. Jaume I, Spain; ²Dept. of Electrical and Computer Engineering, Univ. of Connecticut, USA. The work here presented uses 3D information provided by Synthetic Aperture Integral Imaging (SAII) with a particular focus on the type of the quality of 3D information recovered some challenging partially occluded conditions.

SW3H.1 • 13:30 **Invited**

Lasers for LIDAR & LIDAR Systems: Recent Developments at Quantel and Keopsys, Spanning Pulsed Laser Diodes, Eyesafe Fiber Lasers and High Average Power DPSS Lasers, Patrick Maine¹, Guillaume Canat², Frédéric Chiquet², Céline Canal¹, Paul Wazen¹; ¹QUANTEL SA, France; ²KEOPSYS, France. Keopsys and Quantel have joined forces and are a laser designer of choice for many in the LIDAR community, from science to industry to space agencies. We will discuss the latest LIDAR targeted laser developments we have made for Automotive, Wind, 3D survey, Temperature and Pollutant detection.

PW3H.1 • 13:30 **Invited**

An Analysis of Near-Surface Turbulence and Aerosol Concentration Coupling during a Solar Eclipse, Steven Fiorino¹, Kevin Keefer¹, Lee Burchett², Aaron Archibald¹; ¹Air Force Inst. of Technology, USA; ²Booz Allen Hamilton, USA. Paper links dynamics of near-surface aerosol particles with meteorological observations as well as derived optical turbulence during a solar eclipse while suggesting causes for the unanticipated direct correlation of turbulence fluctuations and aerosol particle counts.

OW3J.1 • 13:30 **Invited**

Adaptive Optics and Wavefront Metrology for High-Intensity Laser Systems, Christophe Dorrier¹; ¹Univ. of Rochester, USA. Focusing laser beams to a tight high-intensity focal spot requires good wavefront quality. Devices and methods for the characterization and modulation of optical wavefronts in high-intensity laser systems are reviewed.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Computational Optical Sensing and Imaging

Largo/Longboat

Laser Applications to Chemical, Security and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

Orange/Lemon

Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AW3A • Animal Optics: The Facts of Light—Continued

AW3A.3 • 14:00

Bacterial Species Identification Using SYTO 9, Claire Honney¹, Cushla M. McGoverin^{2,1}, Scott Choi³, Yaqub Jon-mohamadi¹, Simon Swift¹, Frederique Vanholsbeeck^{2,1}; ¹Univ. of Auckland, New Zealand; ²Dodd-Walls Centre for Photonics and Quantum Technologies, New Zealand; ³Veritide Ltd, New Zealand. Rapid bacterial species identification is necessary in the food industry and medicine. We have investigated the fluorescence spectra collected from several stained bacterial species for the purpose of identifying species specific signatures.

AW3A.4 • 14:15

Impact of structure of compression plates on medical imaging in a diffuse optical tomography system for breast cancer detection: a simulation study, Hao Yang¹, Hanlin Sun², Justin Wong⁴, Xianlin Wei³, Taixiang Shi³, Huabei Jiang¹; ¹Univ. of South Florida, USA; ²Saratoga High School, USA; ³Hualoha Medical Inc, China; ⁴The Lawrenceville School, USA. We present simulation results based on a compression plates based DOT system for breast cancer imaging. Three different structures of compression plate are compared. For the first time, we demonstrate that the parallel-plate provides the best image quality.

CW3B • Machine Learning in Computational Sensing and Imaging I—Continued

CW3B.2 • 14:00 Invited

Optical Sensing and Control Based on Machine Learning, Ryoichi Horisaki^{1,2}; ¹Osaka Univ., Japan; ²JST, PRESTO, Japan. We have introduced machine learning techniques to optical sensing and control. It enables imaging and focusing through random and/or nonlinear phenomena.

LW3C • Techniques for Reactors, Shock Tubes & Cells—Continued

LW3C.2 • 14:00

Gas phase Raman spectroscopy: comparison of continuous wave and cavity based methods, Lee Weller¹, Maxim Kuvshinov¹, Simone Hochgreb¹; ¹Cambridge Univ., UK. Comparison of cavity-enhanced Raman spectroscopy to continuous wave detection for gas phase molecules in air. We show continuous measurements with calculated emission and discuss the potential benefits (two orders more signal) of using a cavity.

LW3C.3 • 14:15

In situ monitoring of aerosols by Raman spectroscopy – particle polymorphism and gas-phase temperature, Leo Bahr^{1,3}, Stefan Will^{2,3}, Andreas S. Braeuer¹; ¹Inst. of Thermal Process Engineering, Environmental and Natural Material Processing, Technische Universität Bergakademie Freiberg, Germany; ²Lehrstuhl für Technische Thermodynamik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; ³Erlangen Graduate School in Advanced Optical Technologies, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany. Our contribution shows a compact sensor system - based on Raman spectroscopy - that is capable of measuring important properties of particle aerosols, like polymorphic modifications and temperature instantly and *in situ*.

MW3D • Application in 3D Microscopy—Continued

MW3D.2 • 14:00

Three-Dimensional Fluorophore Orientation Imaging with Multiview Polarized Microscopy, Talon Chandler¹, Min Guo², Shalin Mehta³, Abhishek Kumar², Hari Shroff², Rudolf Oldenbourg⁴, Patrick La Riviere¹; ¹Univ. of Chicago, USA; ²National Inst.s of Health, USA; ³Chan Zuckerberg Biohub, USA; ⁴Marine Biological Lab, USA. We show that polarized fluorescence microscopes make band-limited measurements in the angular frequency domain. We use this result to propose and demonstrate efficient algorithms for reconstructing three-dimensional fluorophore orientations from multiview polarized microscope data.

MW3D.3 • 14:15 Invited

Splitting Based Methods for Structured Illumination Microscopy., Emmanuel Soubies¹; ¹Ecole Polytechnique Federale de Lausanne, Switzerland. Structured Illumination Microscopy (SIM) provides a good trade-off between spatial and temporal resolutions. This makes SIM a method of choice for imaging biological processes. Here, we present a formulation of the SIM inverse problem that allows for the use of proximity operators which admit closed form expressions. It reduces the computational cost of the associated optimization algorithms.

JW3E • Aerospace Imaging (COSI/IS)—Continued

JW3E.2 • 14:00 Invited

Accelerated Product-based Camera Designs for a Feature-rich Mid-resolution Earth Monitoring Mission, Ignacio Zuleta¹; ¹planet, USA. Here we describe a generalized focal plane design for a mid-resolution, high revisit-rate earth observation mission. We discuss the most significant trade offs and choices and challenges of miniaturizing payloads while keeping the performance on par with missions 100X larger - while increasing higher spectral and spatial resolution. Finally, we discuss how a product an imagery product that is both interoperable and novel can be achieved this way.

Citron

Digital Holography &
3-D Imaging

Clementine

3D Image Acquisition and Display:
Technology, Perception and
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Application of Lasers for Sensing &
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Propagation Through and
Characterization of Atmospheric
and Oceanic Phenomena

Lime

Adaptive Optics: Methods,
Analysis and Applications

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DW3F • Multi-wavelength Digital Holography—Continued

DW3F.2 • 14:00

Synthetic Wavelength Calculation in Dual-illumination Digital Holographic Contouring Without Knowing Illumination Angle and Tilt Angle, Che I. Ping¹, Wen Xiao¹, Feng Pan¹; ¹Key Lab of Precision Opto-mechatronics Technology, School of Instrumentation Science & Optoelectronics Engineering, Beihang Univ., China. We introduce a novel method to compute the synthetic wavelength in dual-illumination digital holographic contouring by using a calibrated step. Notably, the method requires no knowledge about illumination angle and tilt angle.

DW3F.3 • 14:15

Enhanced Quantitative Imaging of Living Cells and Dissected Tissues Utilizing Multi-Spectral Digital Holographic Microscopy, Björn Kemper¹, Alvaro Barroso¹, Lena Kastl¹, Jürgen Schnekenburger¹, Steffi Ketelhut¹; ¹Univ. of Muenster, Germany. We explored, if coherence properties of partial coherent light sources can be generated synthetically utilizing spectrally tunable lasers. The performance of the method is demonstrated by label-free quantitative phase imaging of living pancreatic tumor cells.

3W3G • Light Field Display—Continued

3W3G.2 • 14:00 Invited

Reconfigurable and dynamically tunable droplet-based compound micro-lenses, Sara Nagelberg¹, Lauren D. Zarzar², Kaushikaram Subramanian³, Vishnu Sresht⁴, Daniel Blankschtein⁴, George Barbastathis¹, Moritz Kreysing³, Timothy Swager⁵, Mathias Kolle¹; ¹Dept. of Mechanical Engineering, MIT, USA; ²Dept. of Materials Science and Engineering and Dept. of Chemistry, The Pennsylvania State Univ., USA; ³Max Planck Inst. of Molecular Cell Biology and Genetics, Germany; ⁴Dept. of Chemical Engineering, MIT, USA; ⁵Dept. of Chemistry and Inst. for Soldier Nanotechnologies, MIT, USA. Liquid compound micro-lenses with dynamically tunable focal lengths, inspired by the architectures found in the retina of nocturnal animals are presented. The lenses are formed from bi-phase emulsion droplets that focus light and form images.

SW3H • Components II—Continued

SW3H.2 • 14:00

Single Frequency Er:YAG Methane/Water Vapor DIAL Source, Patrick M. Burns¹, Moran Chen¹, David Pachowicz¹, Slava Litvinovitch¹, Fran Fitzpatrick¹, Nicholas Sawruk¹; ¹Fibertek Inc., USA. Fibertek is developing Pound Drever Hall PDH injection locked, resonantly pumped Er:YAG laser systems for methane and water vapor differential absorption lidar (DIAL). We have achieved 6mJ at 1645nm and a spectral purity of 99.9%

SW3H.3 • 14:15

High Power (51W), Wide bandwidth (25nm), Highly Efficient 1.5 um-WDM Fiber Laser Transmitter for Space Lasercom, Doruk Engin¹, Mark Storm¹, Andrew Schober¹; ¹Fibertek inc, USA. 51W average power, 7 Channel WDM Fiber Laser Transmitter with 25nm flat gain has been demonstrated for optical space communication applications. Power Amplifier supports >10kW/channel SBS limited peak power and achieves o-o efficiency 44%.

PW3H • Environmental Propagation—Continued

PW3H.2 • 14:00

Validation of Tilt Anisoplanatism Models through Simulation, Szymon Gladysz¹, Grigori Filimonov², Valeriy Kolosov²; ¹Fraunhofer Inst. IOSB, Germany; ²V.E. Zuev Inst. of Atmospheric Optics, Russia. The concept of differential motion allows in principle for very precise characterization of optical turbulence. The models for motion decorrelation with increasing distance have to be validated before the technique becomes established. This validation is done here with the help of Monte-Carlo simulations.

PW3H.3 • 14:15

Evaluating a Coupled Mesoscale Modeling and Ray Tracing Framework over an Urban Area, Sukanta Basu¹, Santasri R. Bose-Pillai², Steven Fiorino², Jack E. McCrae²; ¹Delft Univ. of Technology, Netherlands; ²Air Force Inst. of Technology, USA. A newly developed coupled modeling approach is utilized to simulate optical wave propagation over an urban area. The simulated results are validated against a time-lapse imagery-based unique dataset of refractive index gradient.

OW3J • Wavefront/Beam Control & Sensing II—Continued

OW3J.2 • 14:00

Process-oriented adaptive optics control method in the multi-pass laser amplifiers, Qiao Xue¹; ¹Research Center of Laser Fusion, China. The process-oriented adaptive optics wavefront control method is proposed. The experiments validate that the novel approach can effectively prevent the beam quality from worsening and ensure the successful reality of multi-pass laser amplification.

OW3J.3 • 14:15

High Efficiency Laguerre-Gauss (LG) Spectrum Measurement using Variable Focus Lenses, Mumtaz Sheikh^{1,2}, Haad Rathore¹, Sohaib A. Rehman¹, Usman Javid¹, Hamza Ahmed¹, Syed A. Reza¹; ¹Lahore Univ. of Management Sciences (LUMS), Pakistan; ²Forman Christian College (FCCU), Pakistan. We present the design and experimental demonstration of a novel LG spectrum measurement technique in which the detection efficiency of all modes in an unknown, incoming superposition state is simultaneously the maximum possible.

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Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

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AW3A • Animal Optics: The Facts of Light—Continued

AW3A.5 • 14:30

Diffuse optical imaging for breast screening using a dual-direction measuring module of parallel-plate architecture, Jhao-Ming Yu¹, Liang-Yu Chen¹, Min-Cheng Pan², Yi-Ling Lin¹, Sheng-Yih Sun³, Chia-Cheng Chou³, Min-Chun Pan¹; ¹Dept. of Mechanical Engineering, National Central Univ., Taiwan; ²Dept. of Electronic Engineering, Tungnan Univ., Taiwan; ³Tao-Yuan General Hospital, Taiwan. A working prototype of an optical breast imaging system involving a dual-direction parallel-plate scanning scheme in combination with a mammography machine was demonstrated and applied in imaging healthy and malignant breasts in a clinical environment.

AW3A.6 • 14:45 Invited

Photonics and the Primary Industries, Miriam C. Simpson^{1,2}; ¹The Photon Factory, The Univ. of Auckland, New Zealand; ²Physics & Chemical Sciences, The Univ. of Auckland, New Zealand. U. Auckland's Photon Factory applies high-tech lasers to challenges for agriculture: from sperm sorting by sex to "point of cow" diagnostics to mussel bed nutrition. I discuss how advanced photonics underpins primary industries success.

DEMO

Orbis Diagnostics will give dairy farmers the data they need to make decisions about the health, reproductive and nutritional status, and productivity of their herd at a cow-by-cow level. Our "point-of-cow" diagnostics is a new technology that joins centrifugal microfluidics and optical imaging and spectroscopy.

CW3B • Machine Learning in Computational Sensing and Imaging I—Continued

CW3B.3 • 14:30

Deep Learned Phase Mask for Single Image Depth Estimation and 3D scanning, Harel Haim¹, Shay Elmaleh¹, Raja Giryes¹, Alex Bronstein^{1,2}, Emanuel Marom¹; ¹Tel-Aviv Univ., Israel; ²Computer Science, Technion, Israel. Single image depth estimation is achieved using computational imaging and Deep Learning (DL). Imaging with phase-mask is also modeled as a DL-layer, and the mask and DL parameters are jointly designed using labeled data

CW3B.4 • 14:45

Neural Network classification for intensity imaging through multimode optical fibres, Piergiorgio Caramazza^{1,2}, Daniele Faccio², Roderick Murray-Smith³; ¹School of Engineering and Physical Sciences, Heriot-Watt Univ., UK; ²School of Physics & Astronomy, Glasgow Univ., UK; ³School of Computing Science, Glasgow Univ., UK. A neural network algorithm is employed to successfully classify with intensity-only measurements, gray-scale hand-written digits propagated through a multimode fibre, promising an efficient approach for imaging through fibres.

LW3C • Techniques for Reactors, Shock Tubes & Cells—Continued

LW3C.4 • 14:30

Kinetic Studies of HO₂ Radical in a Photolysis Reactor Using Faraday Rotation Spectroscopy, Chu Teng¹, Chao Yan¹, Aric Rouso¹, Timothy Chen¹, Yiguang Ju¹, Gerard Wysocki¹; ¹Princeton Univ., USA. Using a digitally-balanced detection scheme, we perform Faraday Rotation Spectroscopy at 7.2 μm to measure HO₂ formation in a photolysis reactor. Fuel concentration and gas temperature are also quantified in the same laser spectroscopic setup.

LW3C.5 • 14:45

Simultaneous measurement of methane and acetylene based on IH-QCL absorption spectroscopy, Guang Zhang¹, Kuanysh Khabibullin¹, Aamir Farooq¹; ¹King Abdullah Univ. of Sci. & Tech., Saudi Arabia. A novel IH-QCL (integrated heater quantum cascade laser) is used to simultaneously detect methane and acetylene during the high temperature pyrolysis of iso-octane behind the reflected shock waves using scanned-wavelength direct absorption spectroscopy.

MW3D • Application in 3D Microscopy—Continued

MW3D.4 • 14:45

Towards Realistic Superresolution of Incoherent Point Sources, Jaroslav Rehacek¹, Zdenek Hradil¹, Bohumil Stoklasa¹, Martin Paur¹, Andrej Krzic², Jai Grover², Luis L. Sanchez-Soto^{3,4}; ¹Palacky Univ., Czechia; ²European Space Research Technology Centre, Netherlands; ³Universidad Complutense, Spain; ⁴Max-Planck-Institut für die Physik des Lichts, Germany. We establish the multiparameter quantum Cramer-Rao bound for quantum inspired imaging of two incoherent point sources and discuss the optimal detection schemes achieving the ultimate precision predicted by quantum theory thus paving the way for future practical implementations.

JW3E • Aerospace Imaging (COSI/IS)—Continued

JW3E.3 • 14:30 Invited

How to Take a Picture of a Black Hole, Katie Bouman^{1,2}; ¹Massachusetts Inst. of Tec, USA; ²Harvard-Smithsonian Center for Astrophysics, USA. I discuss techniques we have developed to photograph the Milky Way's evolving black hole using a network of ground-based radio telescopes distributed across the globe.

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DW3F • Multi-wavelength Digital Holography—Continued

DW3F.4 • 14:30

Multi-wavelength Digital Holography using Acousto-Optics, Wen-Jing Zhou¹, Ting-Chung Poon¹, Partha P. Banerjee², Ujjitha Abeywickrema²; ¹Dept. of Electrical and Computer Engineering, Virginia Tech, USA; ²Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA. With an acousto-optic frequency shift of 80 MHz, a synthetic wavelength in the order of meters can be achieved. Accurate surface maps are obtained for a multi-depth object using multi-wavelength digital holography without using phase-unwrapping.

DW3F.5 • 14:45

Angular Multiplexed Volume Holograms for Simultaneous Generation of Airy Beam Shapes, Sunil Vyas¹, Yu-Hsin Chia¹, Yuan Luo¹; ¹National Taiwan Univ., Taiwan. To simultaneously obtain three Airy beam shapes from a single holographic optical element, an angularly multiplexed volume holographic grating (AMVHG) is recorded in PQPMMA photopolymer. The wave-length degeneracy property is utilized for the multi-wavelength reconstruction.

3W3G • Light Field Display—Continued

3W3G.3 • 14:30

Systematic Analysis Method for Multilayer Light Field Display, Mohan Xu¹; ¹Univ. of Arizona, USA. We propose a systematic analysis method for the multilayer light field display by simulating the retinal image of a 3D scene rendered at different depths. The retinal image is calculated by convoluting the reconstructed image at test depth and the accumulated point spread function. We evaluate the retinal image with a slope difference method. Then investigate the trade-offs and guidelines for optimal display design.

3W3G.4 • 14:45

Improvement of image quality by using viewpoint following in multi-layer light field display, Ryo Furukawa², Tsukasa Tadano², Shinsaku Hiura², Hiroshi Kawasaki¹; ¹Kyushu Univ., Japan; ²Hiroshima City Univ., Japan. Image qualities of multi-layer light field display depend on the size of viewpoint area. By dividing the light field samples into subsets and reproducing the light field for each subset, the image quality is improved.

PW3H • Environmental Propagation—Continued

PW3H.4 • 14:30

Analysis of Joint Impact of Optical Refractivity and Turbulence on Laser Beam and Image Characteristics, Mikhail A. Vorontsov^{2,1}, Victor A. Kulikov¹, Zhijun Yang¹; ¹Univ. of Dayton, USA; ²Optonicus LLC, USA. The results of numerical analysis demonstrate that an inverse temperature layer (ITL) located in the vicinity of a propagation path could significantly impact the laser beam statistical characteristics and image formation.

PW3H.5 • 14:45

Evidence of Anisotropic Optical Turbulence Over Runway, Melissa K. Beason¹, Joseph Coffaro¹, Christopher Smith¹, Jonathan Spychalski¹, Frank Sanzone¹, Franklin Titus¹, Bruce Berry¹, Robert Crabbs¹, Larry Andrews¹, Ronald L. Phillips¹; ¹Univ. of Central Florida, CREOL, USA. Scintillation index for a Gaussian beam calculated from data taken over a runway in August 2017 is presented which shows evidence of anisotropic conditions early and late in the day and isotropic conditions during midday.

OW3J • Wavefront/Beam Control & Sensing II—Continued

OW3J.4 • 14:30

High Beam Quality of the Third Harmonic for the SG-II Super Beamlet Using Improved Adaptive Optics Technology, Haidong Zhu¹, Chong Liu¹, Ping Zhu¹; ¹SIOM, CAS, CHINA, China. we especially improved the numerical algorithm of adaptive optics to further correct the low spatial frequency wavefront of 1ω , at $1.053\mu\text{m}$, in this paper. The far field of the third harmonic of 3ω has been significantly enhanced from the 27 times to the 12 times diffraction limit for the SG-II Super Beamlet.

OW3J.5 • 14:45

The Exo-Life Finder (ELF) Telescope: Advanced strategies for Extreme Adaptive Optics and cophasing for an extremely large telescope dedicated to extremely high contrast, Maud P. Langlois¹, Jeff Kuhn², GIL MORETTO¹, Michel Tallon¹, Eric Thiébaud³, Andrew Norton⁴, Magali Loupias¹, Svetlana Berdyugina⁵; ¹CNRS, France; ²Institut for astronomy, USA; ³Université de Lyon, France; ⁴Stanford Univ., USA; ⁵KIS, Germany. We present new strategies for building a giant telescope dedicated to exoplanetary life signal with large circular segments using extreme adaptive optics correction independently for each of these segments.

Sunset/Fleming	Siesta/Biscayne	Largo/Longboat	Cedar/Marathon	Orange/Lemon
Applied Industrial Optics	Computational Optical Sensing and Imaging	Laser Applications to Chemical, Security and Environmental Analysis	Mathematics in Imaging	Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

AW3A • Animal Optics: The Facts of Light—Continued

CW3B • Machine Learning in Computational Sensing and Imaging I—Continued

CW3B.5 • 15:00
Phase Unwrapping Using Residual Neural Networks, Gili Dardikman¹, Natan T. Shaked¹; ¹Dept. of Biomedical Engineering, Tel Aviv Univ., Israel. We demonstrate 2-D phase unwrapping of optically thick objects in quantitative phase microscopy, using a deep neural network trained on data consisting of steep spatial gradients.

CW3B.6 • 15:15
Bending-Independent Imaging through Glass-Air Disordered Fiber Based on Deep Learning, Jian Zhao¹, Yangyang Sun¹, Zheyuan Zhu¹, Donghui Zheng², Jose Enrique Antonio-Lopez¹, Rodrigo Amezcua Correa¹, Shuo Pang¹, Axel Schülzgen¹; ¹CREOL, College of Optics and Photonics, Univ. of Central Florida, USA; ²School of Electronic and Optical Engineering, Nanjing Univ. of Science and Technology, China. We demonstrate a bending-independent imaging system for the first time by combining deep neural networks (DNNs) and a meter-long silica-air disordered optical fiber. High-quality artifact-free images can be reconstructed from the transported raw images.

LW3C • Techniques for Reactors, Shock Tubes & Cells—Continued

LW3C.6 • 15:00
Strategy for Determining Absolute Concentration Levels of SiO in Low Pressure Gas Phase Synthesis Flames for Silica Nanoparticles, Robin Chrystie¹, Felix Ebertz¹, Thomas Dreier¹, Christof Schulz¹; ¹IVG, Universität Duisburg-Essen, Germany. Silica nanoparticles are conveniently synthesized in gas phase H₂/O₂ premixed flames and a silicon-carrying precursor (e.g., hexamethyldisiloxane, HMDSO). For flame kinetics mechanism validation including particle growth a technique for absolute concentration measurements of the intermediate SiO based on laser-induced fluorescence and Rayleigh scattering is demonstrated.

LW3C.7 • 15:15
Development of Hollow Cathode Cell for Sputtering of Metal Samples from Electrodes, Daisuke Ishikawa¹, Yuta Yamamoto¹, Fumiko Yoshida¹, Yoshihiro Iwata¹, Shuichi Hasegawa¹; ¹the Univ. of Tokyo, Japan. A hollow cathode glow discharge plasma cell has been developed to vaporize samples placed on electrodes. We have shown possibility to apply this system to gases, liquid residues, and solid metals for nuclear engineering waste.

MW3D • Application in 3D Microscopy—Continued

MW3D.5 • 15:00
Mathematical Tools for Regularized Coherence Retrieval, Zhengyun Zhang¹, Chenglong Bao², Hui Ji³, Zuowei Shen³, George Barbastathis^{4,1}; ¹Singapore-MIT Alliance for Res & Tech Ct, Singapore; ²Yau Mathematical Sciences Center, Tsinghua Univ., China; ³Dept. of Mathematics, National Univ. of Singapore, Singapore; ⁴Dept. of Mechanical Engineering, MIT, USA. We have developed a rigorous forward model, appropriate regularizers and a numerical algorithm that comprise a mathematical framework for coherence retrieval a.k.a. phase space tomography, which enables estimating the state of coherence from intensity measurements.

MW3D.6 • 15:15
Turbulent flow in coherent speckle, Aamod Shanker¹, Girish Nivarti², Laura Waller¹, Carola-Bibiane Schoenlieb²; ¹Univ. of California Berkeley, USA; ²Univ. of Cambridge, UK. Concepts of flow in turbulent fluids are extended to the transport of optical energy and optical phase in coherent laser speckle. The momentum and mass transport of the Navier-Stokes equations translate directly to the intensity and phase transport equations in scalar diffraction theory, since light acts like a pure, incompressible, inviscid fluid. The non-linear term in the phase transport equation describes the emergence of cusps and singularities, shown with measurements of propagated speckle intensity from a diffusive surface.

JW3E • Aerospace Imaging (COSI/IS)—Continued

JW3E.4 • 15:00
Snapshot Spectral Imaging Experiment on Tethered Balloon, Jianrong Wu¹, Enrong Li¹, Xia Shen¹, Zhishen Tong¹, Chenyu Hu¹, Zhenao Liu¹, Liu S. Ying¹, Shensheng Han¹; ¹Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China. Snapshot spectral imaging is conducted with the prototype of spectral camera based on ghost imaging via sparsity constraint (SC-GISC) loaded on the tethered balloon. The distinguishable size is 0.34m@1km. The rRMSE for the reconstructed spectral distribution of the eight color targets is 0.65.

15:30–16:30 Coffee Break with Exhibitors, Palms Foyer

Citron	Clementine	Mandarin	Tangerine	Lime
Digital Holography & 3-D Imaging	3D Image Acquisition and Display: Technology, Perception and Applications	Application of Lasers for Sensing & Free Space Communication	Propagation Through and Characterization of Atmospheric and Oceanic Phenomena	Adaptive Optics: Methods, Analysis and Applications

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DW3F • Multi-wavelength Digital Holography—Continued

DW3F.6 • 15:00

Three-wavelength phase-shifting interferometry with six wavelength-multiplexed holograms, Tatsuki Tahara^{1,2}, Reo Otani³, Yasuhiko Arai¹, Yasuhiro Takaki⁴; ¹Kansai Univ., Japan; ²PRESTO, Japan Science and Technology Agency, Japan; ³SIGMAKOKI CO. LTD., Japan; ⁴Tokyo Univ. of Agriculture and Technology, Japan. We propose three-wavelength phase-shifting interferometry with six wavelength-multiplexed images and specific phase shifts. Three object waves are analytically derived. A three-dimensional surface shape is reconstructed with multiwavelength phase unwrapping.

DW3F.7 • 15:15

Direct phase retrieval with single-shot dual-wavelength digital holography, Junwei Min¹, Meiling Zhou¹, Xun Yuan¹, Kai Wen¹, Baoli Yao¹; ¹Xi'an Inst Optics & Precision Mech CAS, China. By using the single-shot recorded in-line dual-wavelength hologram, the quantitative three-dimensional image of the specimen can be retrieved. Skipping the phase-shift makes the proposed method computationally fast and the practicability is demonstrated.

3W3G • Light Field Display—Continued

3W3G.5 • 15:00

Dense Multi-view Autostereoscopic Three-Dimensional Display System Based on Shutter Parallax Barriers with Dynamic Control, Yang Meng¹, Laurence L. Chen^{1,2}, Zhongyuan Yu¹, Chunyu Zhang¹, Yumin Liu¹; ¹Beijing Univ of Posts & Telecom, China; ²4D perception LLC, USA. An autostereoscopic three-dimensional (3D) system using a two-dimensional display panel and a customized shutter-parallax-barrier screen in front is proposed. The modeling of multiple view zones and system design analysis are described. The simulated results show the high density of viewpoints.

3W3G.6 • 15:15

The Image Processing and Data Analysis of Dense Multi-view Autostereoscopic 3D Display System Based on Dynamic Parallax Barriers, Chunyu Zhang¹, Yang Meng¹, Laurence L. Chen^{1,2}, Zhongyuan Yu¹, Yumin Liu¹; ¹Beijing Univ of Posts & Telecom, China; ²4D perception LLC, USA. It is important for autostereoscopic 3D display system of dense multi-view based on dynamic parallax barriers that image processing and data analysis. Imaging reconstruction technique based on principle of novel system is proposed. This demands good cooperation between image and dynamic parallax barriers. The pixel structure of imaging reconstruction is optimized within allowable crosstalk limits and brighter luminance. The result shows that image structure plays an important role on the effect of 3D display in the best viewing zone.

PW3H • Environmental Propagation—Continued

PW3H.6 • 15:00

Impact of Strong Refractive Index Gradients on Laser Beam Propagation through Deep Turbulence, Victor A. Kulikov¹, Sukanta Basu², Mikhail A. Vorontsov^{1,3}; ¹Univ. of Dayton, USA; ²Faculty of Civil Engineering and Geosciences, Delft Univ. of Technology, Netherlands; ³Optonicus LLC, USA. Atmospheric modeling shows that strong refractive index gradients can appear in the surface layer during certain periods of the diurnal cycle. These gradients and associated turbulence can significantly impact laser beam propagation.

OW3J • Wavefront/Beam Control & Sensing II—Continued

15:30–16:30 Coffee Break with Exhibitors, Palms Foyer

JW4A.1

Holographic Display using Volume Holographic Recording Medium, Dae-Youl Park¹, Jae-Hyeung Park¹; ¹Inha Univ., South Korea. We propose a holographic display technique that reproduces complex optical field by combing analog hologram and digital referencing. In the proposed method, large number of basis light are pre-recorded in a volume holographic recording medium and they are optically addressed and reconstructed by using a spatial light modulator.

JW4A.2

Mid-Infrared Laser Heterodyne Radiometry for Ground-based Monitoring of GHGs in the Atmospheric Column, Weidong Chen¹; ¹Universite du Littoral, France. A mid-infrared laser heterodyne radiometer was developed for ground-based remote measurements of greenhouse gases (GHGs) in the atmospheric column.

JW4A.3

Stain-Free Interferometric Phase Microscopy of Individual Sperm Cells and Machine Learning Analysis, Natan T. Shaked¹, Simcha Mirsky¹, Itay Barnea¹, Mattan Levi¹, Hayit Greenspan¹; ¹Tel-Aviv Univ., Israel. Human sperm cells were imaged using interferometric phase microscopy, features were extracted, and a support vector machine was trained to classify sperm cells by morphology. Precisions of 90% and higher were obtained.

JW4A.5

High-speed Quantitative 3D Blood Flow Imaging by Dual-illumination Holographic Microscopy, Dario Donnarumma¹, Nitin Rawat¹, Alexey Brodoline¹; ¹Laboratoire Charles Coulomb, France. A multidirectional holographic microscopy setup using two illumination beams with a large angle of separation (90 degrees) is proposed to image blood microcirculation in preclinical models. This setup allows an easier manipulation of the sample.

JW4A.6

3D object encryption scheme based on Fresnel diffraction and fractional Fourier transform, Mei-Lan Piao¹, Zi-Xiong Liu¹, Hui-Ying Wu², Nam Kim²; ¹Jilin Univ., China; ²Chungbuk National University, South Korea. We propose a 3D object encryption scheme based on Fresnel diffraction and fractional Fourier transform with two phase only masks. The numerical simulations show that the method is effective and suitable for encrypting 3D object.

JW4A.7

Holographic Tomography with Spherical Wave Illumination, Julianna Winnik¹, Tomasz Kozacki¹, Bryan M. Hennelly^{2,3}; ¹Inst. of Micromechanics and Photonics, Warsaw Univ. of Technology, Poland; ²Dept. of Electronic Engineering, National Univ. of Ireland, Maynooth, Ireland; ³Dept. of Computer Science, National Univ. of Ireland, Maynooth, Ireland. The paper investigates the influence of spherical wave illumination on the reconstruction process in holographic tomography. Moreover, it proposes a reconstruction algorithm that accounts for spherical wave illumination. The algorithm is tested using numerical simulations.

JW4A.8

Reconstruction quality improvement of digital holograms using multi-scale global search, Ravi shekhar², Gopinathan Unnikrishnan², Naveen K. Nishchal¹; ¹Indian Inst. of Technology Patna, India; ²Defence Inst. of Advanced Technology, India. Reconstructed images need quality improvement because of issues related to inaccuracy related to reconstruction distance. A multi-scale global search and fine level curve fitting technique can be seen as an alternative to obtain the best reconstruction.

JW4A.9

Hybrid In-line and Off-axis Digital Holography with Single-shot Dual-wavelength, Dayong Wang¹, Fengpeng Wang¹, Jie Zhao¹, Yunxin Wang¹, Lu Rong¹; ¹Beijing Univ. of Technology, China. The in-line and off-axis digital holograms with different wavelengths are recorded by a color camera with a single shot. The reconstruction is carried using an iterative algorithm. Then higher quality amplitude and phase images can be retrieved, which are verified by experiments.

JW4A.10

High-Resolution Holographic Projection Based on a Coherent Matrix of Spatial Light Modulators, Adam Kowalczyk¹, Izabela Ducin¹, Michal Makowski¹; ¹Faculty of Physics, Warsaw Univ. of Technology, Poland. Experimental results of holographic image projection with the use of a collective matrix of two phase-only SLMs. We have achieved a controlled field interference from both modulators and observed increased resolution in one direction.

JW4A.11

Quality enhancement of Digital Holography by averaging of wavelength-filtered LED, Janghyun Cho¹, Sungbin Jeon¹, Jinsang Lim¹, No-Cheol Park¹; ¹Yonsei Univ., South Korea. By adding bandpass filter with rotation, we propose the quality-enhanced low-coherence digital holography. Without complexity, averaging multiple wavelength-modulated holograms could reduce speckle or systematic noise, which is verified by quantitative analysis.

JW4A.12

Beam Shaping by a Stack of Fizeau Wedges for Metrology, Elena Stoykova¹, Marin Nenchev², Margarita Deneva², Youngmin Kim³; ¹Inst Optical Materials & Tech to the BAS, Bulgaria; ²Optoelectronics and Laser Eng. Dept., Technical Univ. - Plovdiv Branch, Bulgaria; ³Korea Electronics Technology Inst., South Korea. Existence of multiple transmission peaks for a single Fizeau wedge limits its application in metrology. We have shown by an angular spectrum method and experiment that a stack of Fizeau wedges has extended spectral range.

JW4A.13

Low-cost/high-yield fabrication of microlens array for light-field imaging, Hyun Myung Kim¹, Min Seok Kim¹, Young Min Song¹; ¹Gwangju Inst. of Science and Technol, South Korea. We present a fabrication method of microlens array with large-area/low-cost. We also produce a hand-crafted light field camera using the customized microlens array and demonstrate a light field imaging feature.

JW4A.14

Monitoring of Gaseous CO₂ in the Headpace of Champagne Glasses by Infrared Laser Spectrometry, Raphael Vallon¹, Anne-Laure Moriaux¹, Bertrand Parvite¹, Clara Cilindre¹, Gerard Liger-Belair¹, Virginie Zeninari¹; ¹Universite de Reims Champagne-Ardenne, France. We report the development, the validation and the application of an infrared diode laser spectrometer devoted to the monitoring of gaseous carbon dioxide in the headspace of Champagne and sparkling wines glasses.

JW4A.15

Glasses-free stereoscopic imaging based on a distant binocular filter with mutually antiphase liquid crystal layers, Vasily A. Ezhov¹, Peter Ivashkin¹, Alexander Galstian¹; ¹Coherent and nonlinear optics, GPI RAS, Russia. A distant binocular filter with mutually antiphase nematic liquid crystal layers allows to implement glasses-free stereoscopic imaging even at very short (millisecond) durations of images of 3D scene views. Experimental results are presented for selection of optical pulses of view images with both edges of 0.1 ms.

JW4A.16

Spatially Offset Raman Spectroscopy of NaNO₃ Under PTFE layer, Xiaohua Zhang¹, Qiushi Liu¹, Yuchen Li¹; ¹China Inst. of Atomic Energy, China. A kind of opaque PTFE container was devised, and the spatially offset Raman spectra of NaNO₃ powder contained in it have been measured and analyzed for the first time.

JW4A.17

Green Laser Photoswitchable Azobenzene Polymers for Rewritable Hologram with High Diffraction Efficiency, Jae-Won Ka¹, Inhye Jeon¹, Mijin Choi¹, Aejin Yeon¹, Hak Rin Kim²; ¹KRICT, South Korea; ²School of Electronics Engineering, Kyungpook National Univ., South Korea. In order to develop a green laser rewritable hologram material, azobenzene monomers and polymers were synthesized and holographic properties such as diffraction efficiency, rewritability were measured. As a result, it has been found that even if repeated recording and rewriting are performed, the recording medium is maintained in a stable state and we confirmed that G#-5/95, which has an absorption wavelength more suitable for green laser (532 nm), has higher diffraction efficiency than G-5/95

JW4A.18

Imaging of Tear Film Lipids Using Quantum Dots, Maitreyee . Roy¹, Sidra Sarwat¹, Peter O'Mara¹, Mazin Almaini¹, Richard Tilley¹, Justin Gooding¹, Mark Willcox¹, Fiona Stapleton¹; ¹Univ. of New South Wales, Australia. We report on the development of a novel optical imaging technique for visualizing tear film lipid using scandium doped silicone quantum dots with varying surface chemistries; lipophilic and hydrophilic.

JW4A.19

Laser Speckle Noise Suppression using a Rotating Diffuser in Optimal Modified Lateral Shearing Interferometer, Kwang-Beom Seo¹, Ho-Chul Lee¹, Seung-Ho Shin¹; ¹Physics, Kangwon National Univ., South Korea. We propose laser speckle noise suppression using a rotating diffuser in an optimal modified lateral shearing interferometer. We have confirmed that the phase errors caused by the laser speckle noise are reduced in reconstruction.

JW4A.20

Stimulated Raman with Broadband LED Stokes Source for Analysis of Glucose and Hemoglobin, Peter S. Bullen¹, Ioannis Kymissis¹, Adler Perotte²; ¹Columbia Univ., USA; ²Columbia Univ. Medical Center, USA. We demonstrate stimulated Raman gain using a broadband LED Stokes source in vibrational modes of glucose and hemoglobin. This versatile and cost-effective method increases the signal of Raman modes within the LED spectrum.

JW4A.21

Image Achromatization for Conical Multiplex Hologram, Yih-Shyang. Cheng¹, Fu-Shiuan Guo¹; ¹Dept. of Optics and Photonics, National Central Univ., Taiwan. With a filtering-slit oriented at the achromatic angle, master hologram is recorded as a disk hologram. Retrieved information is then directly recorded on conical holographic film. The regenerated image from final hologram show achromatization.

JW4A.22

Impact on the Fidelity of Hyperspectral Imagery Produced by a Phenoptic Hyperspectral Imaging System, Timothy J. Lindsey¹, R. Barry Johnson¹; ¹Alabama A&M Univ., USA. A simulation of a "perfect" telecentric hyperspectral phenoptic imager has been constructed to determine image fidelity resulting from diffractive spectral contamination and its comparison to imagery produced by a Surface Optics SOC716 VNIR hyperspectral camera.

JW4A.23

Using computer vision methods for the measurement of freeform surfaces with experimental ray tracing, Tobias Binkle¹, David Hilbig¹, Friedrich Fleischmann¹, Thomas Henning¹; ¹City Univ. of Applied Sciences Bremen, Germany. Experimental Ray Tracing has proven its abilities in many different applications. We use this technique and combine it with the high efficient methods of computer vision to create a new measurement technique for specular surfaces.

JW4A.24

Learning-based Single Shot Phase Retrieval for Reflective Digital Holographic Microscopy, Dongheon Yoo¹, Byounggho Lee¹, Jaebum Cho¹, Byounggho. Lee¹; ¹Seoul National Univ., South Korea. We propose the novel single shot phase retrieval method using machine learning algorithm for reflective digital holographic microscopy. The feasibility of this method is verified through experiments with fingerprint specimens.

JW4A.25

A Simple Fringe Pattern Profilometry Phase-shift Error Quantification Method, Lin Wang^{3,1}, Hongbo Zhang², Yu Xin³; ¹Virginia Polytechnic Inst. and State Univ., USA; ²Virginia Military Inst., USA; ³Nanjing Univ. of Science and Technology, China. We propose a method to acquire the real value of phase-shift from the capture images in fringe pattern profilometry, it helps to improve the quality of 3D shape reconstruction.

JW4A.26

A Conversion Method of 2D Image into 3D Holographic Projection, Lin Hu¹, Yunxiu Shui¹, Gang Zhu¹, Yan Yang¹; ¹Chongqing Univ. of technology, China. In order to realize the holographic display by a 2D image and to suppress speckle noise of reconstructed images, Fresnel kinoform is calculated by adding the phase information, which is obtained based on the gray curve of a 2D image by computing a polynomial equation into initial phase factor of a complex object. A vivid holographic reconstructed projection image with real phase information can be observed with naked eye.

JW4A.27

Study of heterogeneous dynamics by Holographic Time Resolved Correlation (HTRC), Michel Gross¹, Adrian M. Philippe¹, Luca Cipelletti¹, Anne C. Genix¹; ¹Laboratoire Charles Coulomb UMR5221 CNRS - Université Montpellier, France. HTRC is a new light scattering technique that measures by holography the field amplitude scattered by a sample, and analyze its spatial correlations. HTRC outperforms other light scattering techniques like DLS, DWS and TRC.

JW4A.28

Digital Holography Reconstruction for 3D Muller-Matrix Imaging of Phase-Inhomogeneous Objects, Igor Panko¹; ¹Chernivtsi National Univ., Ukraine. A new principle for recording information about the structure of optically inhomogeneous layers is proposed. Principles of variations in the state of polarization of illuminating laser radiation using a reference wave are used. The digital holographic algorithm for obtaining three-dimensional Muller-matrix images of phase-inhomogeneous layers is presented. The azimuthally invariant parameters that characterize the layered anisotropy of biological layers are found.

JW4A.29

Measurement of microfluidic refractive index by digital holographic microscopy, Chan Sun¹, Yutong Cui¹, Zhe Wang¹, Zhuqing Jiang¹; ¹College of Applied Sciences, Beijing Univ. of Technology, China. A measurement of microfluidic refractive index is presented by digital holography. Salt solutions of different concentrations are each injected within microfluidic chip, and their refractive indexes are obtained according to the digital holographic phase imaging.

JW4A.30

Evaluation of Shape Influence on Spheroidal Particle Size Characterization by Light Extinction Method, Yi Zhou¹, Jun Chen¹, Huinan Yang¹, Tan Li¹, Mingxu Su¹; ¹USST, China. By combining extinction spectrum prediction based on the generalized Mie theory with regularization inversion algorithm, the effect of particle shape on particle size characterization in multi-wavelength light extinction method is evaluated numerically and then concluded.

JW4A.31

Obtain point spread function of scattering medium via spatial correlation, Huizu Lin¹, Quan Li¹, WeiTao Liu¹; ¹Natl Univ Def Tech, China. We propose to measure intensity transmission matrices of diffusers then point-spread-function (PSF) of scattering medium via spatial correlation with incoherent light. Possible applications in imaging are also discussed.

JW4A.32

Applying Analytical Solution of Diffusion Equation to Verify Diffuse Optical Imaging System, Liang-Yu Chen¹, Ya-Ting Liang¹, Zhao-Ming Yu¹, Min-Cheng Pan², Min-Chun Pan¹; ¹Dept. of Mechanical Engineering, National Central Univ., Taiwan; ²Dept. of Electronic Engineering, Tung-Nan Univ., Taiwan. We applied analytical solution of diffusion equation to verify diffuse optical imaging system by comparing the solution and measurement data. A high scattering Lipovenoes phantom was designated to verify our circular scanning imaging system.

JW4A.33

Chromatic aberration analysis in holographic image combiner for Bragg mismatch condition, Seokil Moon¹, Dukho Lee¹, Byounggho. Lee¹; ¹Seoul National Univ., South Korea. Eye box enlargement in augmented reality (AR) head mounted display (HMD) system is a crucial issue. Expansion of the eye-box formed from the holographic image combiner can be achieved by exploiting Bragg mismatch condition in holographic optical elements (HOEs). In this paper, analysis of chromatic aberration in holographic image combiner is carried out with experimental set up and results when Bragg condition is not satisfied.

JW4A.34

Enhancing the Edge Detection by Gradient-Plus-Canny Filters, Miguel Mora-González¹, Ricardo Sevilla-Escoboza¹; ¹Universidad de Guadalajara, Mexico. In this work the development of a hybrid edge detector for the application of fill regions, based in the compass gradient convolution mask and the Canny operator, is presented. The results obtained were an edge detector with higher resolution, more sections detected and a larger filling area in the image. The method was compared with traditional edge detectors obtaining favorable results.

JW4A.35

Fluence calculation using portal images, Rakesh Manjappa¹, Vyankatesh Sheja³, Rajesh Kumar², Rajan Kanhirodan¹; ¹Indian Inst. of Science, India; ²RPAD, BARC, India; ³Radiotherapy, Manipal Hospital, India. Radiotherapy treatment has seen major improvements in plan quality since advent of intensity modulation (IMRT). Fluence computation is crucial for dose verification. In this study, we calculate fluence from EPID measurements and compare it with Treatment planning system (TPS).

JW4A.36

High Accuracy 3D face reconstruction from single 2D image, Tao Yang^{1,2}; ¹*Xi'an Jiaotong Univ., China*; ²*Media Lab, MIT, USA*. This paper proposes a high accuracy 3D face model reconstruction method which is based on machine learning algorithm. The framework contains a features auto-encoder and a Generative-Adversarial Network. We use more than 20,000 high quality 3D face medal to train this network.

JW4A.37

Implementation of a graphical interface for an adaptive optics system **Implementation of a graphical interface for an adaptive optics system**, Marco A. Betanzos-Torres^{1,2}, Eva O. Barrera Martinez², Juan Castillo Mixcoatl¹; ¹*Benemérita Univ Autonoma de Puebla, Mexico*; ²*Sistemas Automotrices, Universidad Tecnológica de Puebla, Mexico*. In this work, a graphical interface is presented, which allows to understand and interpret the principle of an adaptive optics system, when you want to dabble into this area of research for the first time.

JW4A.38

Dither-Enhanced Lidar, Joshua Rapp^{1,2}, Robin M. Dawson², Vivek K. Goyal¹; ¹*Boston Univ., USA*; ²*Draper, USA*. We present the design of a subtractively-dithered time-correlated single photon counting ranging system, resulting in improved depth resolution.

NOTES

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Computational Optical Sensing
and Imaging

Largo/Longboat

Laser Applications to Chemical, Security
and Environmental Analysis

Cedar/Marathon

Mathematics in Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30

AW5A • Orlando: The New Silicon Valley?

Presider: Arlene Smith; Avo Photonics, USA

AW5A.1 • 16:30

UCF Business Incubation Program - The First Twenty Years, Gordon Hogan, *Director, UCF Business Incubation Program, USA*. Abstract not provided.

Panel • 17:00

While Silicon Valley is widely thought of as the heart of technical entrepreneurship, in recent years Orlando has gained prominence as a new hub of innovation. Is Central Florida the new home for Photonics start-ups?

Panel

Alexandre Fong, *Hyperspectral Imaging, HinaLea Imaging, USA*

Gordon Hogan, *UCF Business Incubation Program, USA*

16:30–18:30

CW5B • Machine Learning in Computational Sensing and Imaging II

Presider: Aydogan Ozcan; University of California Los Angeles, USA

CW5B.1 • 16:30 **Invited**

Deep Learning for Imaging System Design, Vidya Ganapati¹; ¹Engineering, Swarthmore College, USA. This work uses deep learning for end-to-end design of imaging systems, in order to obtain fast imaging, high resolution, and large field-of-view at the same time. We present examples related to fluorescence localization microscopy and Fourier ptychography.

CW5B.2 • 17:00 **Invited**

Fourier ptychographic imaging and a machine learning approach, Guoan Zheng¹, Shaowei Jiang¹, Kaikai Guo¹; ¹Univ. of Connecticut, USA. We will introduce the principle of the Fourier ptychography approach. We will also discuss the recent developments and a machine learning approach for Fourier ptychography.

16:30–18:30

LW5C • Ultra-fast Techniques & High-speed Imaging II

Presider: Thomas Seeger; Universität Siegen, Germany

LW5C.1 • 16:30 **Invited**

Development of Robust Ultrafast CARS Thermometry and Species Detection, Alexis Bohlin¹; ¹Delft Univ. of Technology, Netherlands. We develop simultaneous spatially-correlated high-repetition-rate gas-phase thermometry, as a unique tool to investigate the stability of distributed auto-ignition combustion modes with reduced emissions of NO_x, particulates, CO and unburned hydrocarbons in a prototype jet-engine combustor.

LW5C.2 • 17:00

Investigation of Femtosecond Two-Photon LIF of CO at Elevated Pressures, Yejun Wang¹, Waruna Kulatilaka¹; ¹Texas A&M Univ., USA. Recent advances of femtosecond two-photon LIF (fs-TPLIF) for CO imaging is explored for high-pressure applications. The overall signal levels, laser pulse energy, and quenching dependencies are studied at elevated pressures up to 10 bars.

LW5C.3 • 17:15

Two- and Three-Photon LIF Detection of Atomic Hydrogen Using Femtosecond Laser Pulses, Ayush Jain¹, Waruna Kulatilaka¹; ¹Texas A&M Univ., USA. Two- and three-photon, femtosecond-duration laser-induced fluorescence (fs-LIF) schemes of atomic hydrogen are investigated. Measured LIF profiles in premixed, methane-air flames are comparable amid different levels of stimulated emission and photoionization effects.

16:30–18:30

MW5D • Model-based Imaging

Presider: Lei Tian; Boston Univ., USA

MW5D.1 • 16:30 **Invited**

Title to be Determined, Charles A. Bouman¹; ¹Purdue Univ., USA. Abstract not available.

MW5D.2 • 17:00

Direct inversion of intensity diffraction tomography with a computational microscope, Waleed Tahir¹, Ling Ruilong¹, Lei Tian¹; ¹Boston Univ., USA. Intensity diffraction tomography (IDT) enables 3D phase recovery from intensity-only measurements. We present a novel IDT technique that enables motion-free, 3D phase and absorption reconstruction using a computationally efficient algorithm.

MW5D.3 • 17:15

Nonconvex Optimization for Diffractive Imaging, Yanting Ma², Hassan Mansour³, Dehong Liu³, Petros Boufounos³, Ulugbek S. Kamilov¹; ¹Washington Univ. in St. Louis, USA; ²North Carolina State Univ., USA; ³Mitsubishi Electric Research Labs, USA. Image reconstruction under multiple scattering of light is often formulated as a nonconvex optimization problem. We describe a new optimization method for image reconstruction under multiple scattering based on a new convergent variant of the popular fast iterative shrinkage/thresholding algorithm (FISTA). The proposed method is suitable for sparsity-driven diffraction tomography where multiple scattering cannot be neglected.

Orange/Lemon

Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Lime

Joint Applied Industrial Optics/ Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:30

JW5E • Spectral Imaging (COSI/IS)

President: Casey Streuber; Raytheon Missile Systems, USA

JW5E.1 • 16:30 **Invited**

A Multispectral Light Field Camera for 3D Imaging from a Single Lens, Antonio Robles-Kelly¹, Ran Wei¹, Shaodi You¹; ¹Data61-CSIRO, Australia. We present a multispectral light field camera configuration which benefits from the spatial resolution of focused plenoptic cameras while exhibiting low angular bias. This delivers a small form-factor 3D chemical imaging platform with ample applications.

JW5E.2 • 17:00

Toward Real-time Terahertz Imaging with Spectral Encoding of the k-space, Hichem Guerboukha¹, Kathirvel Nallappan¹, Maksim Skorobogatiy¹; ¹Ecole Polytechnique de Montreal, Canada. Acquisition time is a major hurdle in terahertz imaging. To reduce the number of pixels, we use spectral encoding in a single-pixel detection scheme. We demonstrate the reconstruction process for amplitude and phase masks.

JW5E.3 • 17:15

Hyperspectral ghost imaging camera based on a flat-field grating, Liu S. Ying^{1,2}; ¹Shanghai Inst of Optics and Fine Mech, China; ²Univ. of Chinese Academy of Sciences, China. We propose a hyperspectral ghost imaging camera based on a flat-field grating, which can improve spectral resolution of spectral camera and provide a possibility of optimizing measurement matrix according to light fields with different wavelengths.

16:30–18:15

DW5F • OptoFluidic and Life Applications of DH

President: Giancarlo Pedrini; Universität Stuttgart, Germany

DW5F.1 • 16:30 **Invited**

Compact Solutions for Off-axis Holography in Optofluidics, Biagio Mandracchia¹, Vittorio Bianco¹, Melania Paturzo¹, Pietro Ferraro¹; ¹Inst. of Applied Sciences and Intell, Italy. The state-of-the-art fabrication of micro-optics gives the opportunity to embed complex optical devices in small spaces. Here we show a compact interferometer on a commercial plastic chip for off-axis Digital Holography microscopy.

DW5F.2 • 17:00 **Invited**

Digital holographic microscopy as means of remote life detection, Gene . Serabyn¹, Kurt Liewer¹, Kent Wallace¹, Chris Lindensmith¹, Jay Nadeau²; ¹Jet Propulsion Lab, USA; ²Portland State Univ., USA. Compact digital holographic microscope configurations are being developed to enable searches for microbial life in remote terrestrial sites and the oceans of outer solar system moons. Rapid volume imaging at sub-micron resolution is provided.

16:30–18:15

3W5G • Interferometry & OCT

President: Yasuhiro Takaki; Tokyo Univ of Agriculture and Technology, Japan

3W5G.1 • 16:30

Real-Time 3-D Processing and Visualization by Optimal Bandwidth Capacity Interferometry, Natan T. Shaked¹, Gili Dardikman¹, Moran Rubin¹; ¹Tel-Aviv Univ., Israel. We suggest new platforms for compressing up to 16 off-axis interferograms into a single interferogram for data compression and real-time 3-D processing and visualization.

3W5G.2 • 17:00 **Invited**

Title to be Provided, Aristide Dogariu¹; ¹Univ. of Central Florida, CREOL, USA. Abstract not available.

16:30–18:30

JW5I • Turbulence & Propagation (pcAOP/AO)

President: Julian Christou; Large Binocular Telescope Observatory, USA

JW5I.1 • 16:30 **Invited**

Optical Turbulence Forecast in the Adaptive Optics Realm, Elena Masciadri¹, Alessio Turchi¹, Luca Fini¹; ¹INAF Osservatorio Astrofisico di Arcetri, Italy. Scientific drivers related to the optical turbulence forecast applied to the ground-based astronomy supported by Adaptive Optics, the state of the art of the achieved results and the most relevant challenges for future progresses are presented.

JW5I.2 • 17:00

Comparison of Measurement Techniques Used to Determine Atmospheric Structure Parameter, Cody A. Fernandez¹, Gisele Bennett¹; ¹Georgia Tech Foundation, Inc, USA. C_n^2 measurements were taken at the recent CABLE/TRAX test at the NASA Shuttle Landing Facility along a 1.5 km horizontal path by three atmospheric turbulence measurement devices (DELTA, PROPS, IACS) and two commercial-grade scintillometers (BLS-900 and K&Z LAS). The fundamental operating principles of these devices and their measurement data are analyzed for consistency in measurement outcomes.

JW5I.3 • 17:15 **Invited**

Adaptive Optics Correction for Oceanic Turbulence-Affected Laser Beams, Italo Toselli¹, Szymon Gladysz¹; ¹IOSB, Fraunhofer, Germany. We investigate theoretically the performance of adaptive-optics correction for Gaussian beams affected by oceanic turbulence. Action of adaptive optics is modeled as removal of a certain number of Zernike modes from the aberrated wavefront. We found that, similarly to atmospheric turbulence, adaptive optics is very effective in improving optical system performance of laser communication links in weak oceanic turbulence.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Computational Optical Sensing
and Imaging

Largo/Longboat

Laser Applications to Chemical, Security
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Mathematics in Imaging

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AM5A • Orlando: The New Silicon Valley?—Continued

CW5B • Machine Learning in Computational Sensing and Imaging II—Continued

CW5B.3 • 17:30

Speckle suppression using the convolutional neural network with an exponential linear unit, Tianjiao Zeng¹, Zhenbo Ren¹, Edmund Y. Lam¹; ¹EEE, Univ. of Hong Kong, Hong Kong. We describe a convolutional neural network for image despeckling with the exponential linear unit activation function, which outperforms state-of-the-art approaches on the reduction of speckle noise.

Panel • 17:45

Deep Learning

Deep Learning is a learning paradigm that seeks to discover increasingly abstract representations of data by cascading several processing layers that each progressively transform the input into more abstract representations. By compositing enough of these transformations, it is possible to learn highly complex input-output relationships. The above simple learning paradigm has significantly improved the state-of-the-art in speech recognition, visual object recognition, object detection and other domains including drug discovery and genomics. In recent times, Deep Learning has been used to tackle a variety of inverse problems in imaging ranging from imaging through scattering media to Phase Retrieval and Super-Resolution.

This panel discussion seeks to promote a broader discussion on the topic and help identify newer opportunities, while addressing misgivings about Deep Learning. The panel will be moderated by Aydogan Ozcan and will include imaging experts that practice the art of Deep Learning.

Panelist

George Barbastathis, *MIT, USA*

Bahram Jalali, *UCLA, USA*

Vidya Ganapathi, *Swarthmore College, USA*

LW5C • Ultra-fast Techniques & High-speed Imaging II—Continued

LW5C.4 • 17:30 **Invited**

Advantages of Ultrafast LIBS for High-Pressure Diagnostics, Anil K. Patnaik¹, Paul S. Hsu¹, Adam J. Stoltz², Jordi estevedeordal², James R. Gord³, Suresh Roy¹; ¹Spectral Energies LLC, USA; ²Dept. of Mechanical Engineering, North Dakota State Univ., USA; ³Aerospace Systems Directorate, Air Force Research Lab, USA. Ultrafast laser generates controlled plasma even at high gas pressures (40 bars), which helps in increasing the measurement stability of the laser-induced breakdown (LIBS) based fuel-air ratio measurement.

LW5C.5 • 18:00 **Invited**

Advanced Optical Diagnostic Approaches for Combustion Systems, Benjamin Emerson¹; ¹Aerospace Engineering, Georgia Inst. of Technology, USA. Recent advances of high repetition rate pulsed laser technology have revolutionized the world of combustion system diagnostics. These diagnostics produce non-intrusive, multi-dimensional measurements such as spatio-temporally resolved velocity vector fields and chemical species fields.

MW5D • Model-based Imaging—Continued

MW5D.4 • 17:30 **Invited**

Binary Sensing Matrix Design for Super-Resolution IR Compressive Imaging, Jun Ke¹, Edmund Y. Lam²; ¹Beijing Inst. of Technology, China; ²The Univ. of Hong Kong, Hong Kong. In IR compressive imaging, diffraction due to small sizes of micro-mirrors affects system resolution besides the resolution of a DMD. To deal with this issue, super-resolution IR compressive imaging with binary sensing matrix design is studied in this work.

MW5D.5 • 18:00

Incoherent Diffraction-Free Space-Time Light Sheets Produced From a Broadband LED, Murat Yessenov¹, Hasan E. Kondakci¹, Monjurul F. Meem², Rajesh Menon², Ayman F. Abouraddy¹; ¹CREOL, Univ. of Central Florida, USA; ²Dept. of Electrical and Computer Engineering, Univ. of Utah, USA. We demonstrate experimentally diffraction-free space-time light sheets produced from a broadband incoherent LED. Self-similar propagation is engendered through tight correlations introduced between the field's spatial and temporal degrees-of-freedom.

MW5D.6 • 18:15

Time Reversal using Bianisotropic Metasurfaces, Nish Chandra¹; ¹Univ of North Carolina Charlotte, USA. Design of two complimentary metasurfaces composed of bianisotropic structures to code and decode the evanescent fields from the sources into propagating waves for analog detection of sources placed at sub-wavelength separation using time reversal.

Orange/Lemon

Joint Computational Optical Sensing and Imaging/Imaging Systems and Applications

Citron

Digital Holography & 3-D Imaging

Clementine

3D Image Acquisition and Display: Technology, Perception and Applications

Lime

Joint Applied Industrial Optics/ Adaptive Optics: Methods, Analysis and Applications

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

JW5E • Spectral Imaging (COSI/IS)—Continued

JW5E.4 • 17:30

Multispectral Wavefront Sensing for Characterizing Spatiotemporal Coupling in Ultrashort Pulses, Seung-Whan. Bahk¹, Christophe Dorrer¹; ¹Univ. of Rochester, USA. A multispectral wavefront sensor is presented based on a lateral shearing interferometry technique and a multispectral image sensor. The measurement of first-order spatiotemporal coupling effects agrees well with the expectation.

JW5E.5 • 17:45

Supervised Classification of Hyperspectral Images using Side Information, Carlos A. Hinojosa¹, Karen Sanchez¹, Henry Arguello¹; ¹Universidad Industrial de Santander, Colombia. This paper proposes a classification method that fuses superpixels-segmentation information from an RGB image with a hyperspectral image without estimating the high spatial-spectral resolution cube. This methodology improves the classification accuracy while boosting the performance.

JW5E.6 • 18:00

Highly Crossalked Integral Field Spectrometer with Computational Inversion, Maciej Baranski¹, Sanathanan S. Muttikulangara¹, George Barbastathis^{2,3}, Jianmin Miao¹; ¹Nanyang Technological Univ., Singapore; ²MIT, USA; ³Singapore-MIT Alliance for Research and Technology (SMART) Centre, Singapore. We investigate integral field spectrometer architecture in the highly crosstalked regime. It allows measurement of spectral datacube with higher spatial and spectral resolution, however it requires computational inversion to obtain spectral datacube. Inversion is based on optimization and employs regularization using low rank prior on the observed object.

JW5E.7 • 18:15

Spectral Imaging Subspace Clustering with 3-D Spatial Regularizer, Carlos A. Hinojosa¹, Jorge L. Bacca¹, Henry Arguello¹; ¹Universidad Industrial de Santander, Colombia. This paper proposes a spectral image clustering approach that uses a 3-D Gaussian filter to incorporate the spatial information of the scene in the Sparse Subspace Clustering model obtaining a more accurate representation coefficient matrix.

DW5F • OptoFluidic and Life Applications of DH—Continued

DW5F.3 • 17:30

Integrated dual-mode tomography for unlabeled free-floating single cell imaging, Yu-Chih Lin¹, Vinoth Balasubramani¹, Xin-Ji Lai¹, Han-Yen Tu², Chau-Jern Cheng¹; ¹National Taiwan Normal Univ., Taiwan; ²Chinese Culture Univ., Taiwan. Integrated dual-mode tomography system is proposed and demonstrated. The spatial frequencies are filled up by full-angle sample and beam rotation, in which a large frequency coverage is obtained to enhance spatial resolution in x-y-z direction.

DW5F.4 • 17:45

Holographic Phase Imaging for Full-field Thickness Mapping of Evolving Thin Liquid Films, Biagio Mandracchia¹, Zhe Wang^{2,1}, Vincenzo Ferraro³, Ernesto Di Maio³, Pier Luca Maffettone³, Pietro Ferraro¹; ¹Inst. of Applied Sciences and Intelligent Systems, Italy; ²College of Applied Sciences, Beijing Univ. of Technology, China; ³Univ. of Naples, Italy. The dynamics of thin liquid films are of great interest to industrial processes and life science. Here we propose a holographic system for the evaluation of the 3D topography and thickness of evolving thin liquid film.

DW5F.5 • 18:00

Improved 3D Imaging of Zebrafish Larvae Microcirculation by Digital Holography, Alexey Brodoline¹, Nitin Rawat¹, Daniel Alexandre¹, Michel Gross¹; ¹Laboratoire Charles Coulomb, France. A microscopic technique based on digital holography is proposed to investigate blood microcirculation and vascular development in model organisms such as zebrafish larvae. Recent achievements in 3D imaging of blood flow in vessels are presented.

3W5G • Interferometry & OCT—Continued

3W5G.3 • 17:30

Digital Phase Conjugation for Improving the Focused Spot in Weakly Scattering Medium for OCT, Keisuke Harukaze¹, Noriyuki Nakatani¹, Xiangyu Quan¹, Kouichi Nitta¹, Osamu Matoba¹; ¹Kobe Univ., Japan. Digital phase conjugation is applied to improve the focusing property in a weakly scattering medium for achieving high-resolution OCT. Experimental results for improving the focusing property are presented.

3W5G.4 • 17:45

Multidirectional holographic interferometer for 3D gas density reconstruction, François Olchewsky¹, Frédéric Champagnat², Jean-Michel Desse¹; ¹ONERA, France; ²ONERA, France. A multidirectional holographic interferometer is built for analyzing and reconstructing the 3D gas density field. It is composed by six different sights of views and the holographic interferograms are processed by 2D Fourier transforms. This interferometer is applied to reconstruct the gas density of 3D laminar helium jet and small supersonic jets.

3W5G.5 • 18:00

3D Image Quality Improvement for Optical Projection Tomography via Point Spread Function Modelling, Xiaojin Tang¹, Gerda Lamers¹, Fons Verbeek¹; ¹Leiden Univ., Netherlands. We present a method to model the 3D point spread function in optical projection tomography imaging system, which subsequently contributes to the improvement of 3D image quality. Experiments are implemented on several 3D images of zebrafish embryos.

JW5I • Turbulence & Propagation (pcAOP/AO)—Continued

JW5I.4 • 17:45

Generating Infinitely Long Phase-Screens with the Karhunen-Loève Decomposition, Szymon Gladysz¹, Esdras Anzuola¹; ¹Fraunhofer Inst. IOSB, Germany. We introduce a method for creating temporally evolving wavefront distortions that uses Karhunen-Loève decomposition and the associated temporal power spectra. We demonstrate that the method is able to produce dynamic wavefronts that follow the behavior predicted by the theory while introducing key advantages in terms of calculation speed and storage in computer memory.

JW5I.5 • 18:00 Invited

Characterising atmospheric turbulence using SCIDAR techniques, James Osborn¹; ¹Physics, Durham Univ., UK. Knowledge of the structure of the Earth's atmospheric turbulence is critical for astronomical adaptive optics well as optical communications. Here we present the state of the art Stereo-SCIDAR technique for night time profiling. This high-sensitivity and high-resolution optical turbulence profiler has been in regular operation on La Palma and Paranal. Here we present the instrument, statistics and comparisons with other profiling instruments and numerical forecast models in the context of AO.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Cedar/Marathon

Digital Holography & 3-D Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:30–16:00 Registration, Palms Foyer

08:00–09:00 Postdeadline Papers (schedule and location listed in the congress update sheet)

09:00–09:45 Coffee Break with Exhibitors, Palms Foyer

09:45–11:45

ATH2A • Another Day, Another Detector

Presider: Garrett Cole; Crystalline Mirror Solutions LLC, USA

ATH2A.1 • 09:45 **Invited**

Cryostats for Cryophobes--a revolutionary "one-button" desktop 1.7 K cryostat for superconducting optoelectronics, Aaron J. Miller¹; ¹Quantum Opus, LLC, USA. I will present an overview of our commercial superconducting photon detector technology and how we expect to reduce the cryogenic barrier-to-entry by the development of the world's first "one-button" desktop 1.7 Kelvin cryostat.

DEMO

Demonstration of the world's first "desktop" one-button cryogenic system operating at 1.7 Kelvin using less than 300 Watts of wall-plug power. A description of the technology and potential novel applications will be discussed in the preceding talk.

ATH2A.2 • 10:30

Non-Absorbing, Point-of-Use, High-Power Laser Power Meter, Alexandra B. Artusio-Glimpse¹, Ivan Ryger¹, Paul Williams¹, John Lehman¹; ¹NIST, USA. We have developed a compact, high-power laser power meter in the form of a folding mirror, precluding the need for beam splitters that considerably increase measurement uncertainty. Furthermore, our symmetric design inhibits responsivity to gravity.

09:45–11:45

ITh2B • Sensors & Optics

Presider: Dale Linne von Berg; US Naval Research Lab, USA

ITh2B.1 • 09:45 **Invited**

CMOS Image Sensor Evolution toward Sensing World, Hirotaka Murakami¹; ¹Sony Electronics Inc., USA. CMOS image sensors have made exceptional advances in sensitivity and resolution. Future evolution will occur along the lines of spectral diversity, 3D sensing, and higher frame rate accomplished with three dimensional system integration.

ITh2B.2 • 10:15 **Invited**

Spherically Curved Image Sensors, Geoffrey McKnight¹, Andrew Keefe¹, Brian Guenter², Neel Joshi², Richard Stoakley², Ryan Freeman¹; ¹MML, HRL Labs, USA; ²Microsoft, USA. We present methods and analysis for the creation of highly curved CMOS and hybridized InGaAs image sensors using a newly developed pneumatic forming technique along with prototype camera performance data.

09:45–11:45

DTh2C • Digital Holographic Microscopy

Presider: Aydogan Ozcan; Univ. of California Los Angeles, USA

DTh2C.1 • 09:45 **Invited**

Telecentric imaging in reflection and transmission digital holographic microscopy, Jorge Garcia-Sucerquia¹; ¹Universidad Nacional de Colombia, Colombia. In this contribution telecentric imaging, both in transmission and reflection digital holographic microscopy (DHM), is reviewed. An analysis of the effects of the microscope objectives in both configurations of DHM is presented. The findings are utilized to show that the most effective method to avoid phase perturbations due to the imaging system of the microscope, is the recording of the digital holograms with an infinity-corrected microscope objective in telecentric configuration with a tube lens. The performance of this recoding architecture for both modes of operation of DHM is analyzed theoretically and validated with experimental results. Transparent biological and reflective non-biological samples are imaged with telecentric-DHM operating in transmission and reflection modes, in that order.

DTh2C.2 • 10:15

Two-coupled Mach-Zehnder interferometers in a multi-camera setup for phase-shifting applied to digital holographic microscopy, Carlos A. Trujillo¹, Jorge Garcia-Sucerquia¹; ¹Univ Nacional de Colombia Medellin, Colombia. The use of two-coupled Mach-Zehnder interferometers for four $\pi/2$ -phase shifting interferometry which includes a multi-camera arrangement is presented. This proposal is validated in digital holographic microscopy to visualize a biological sample of epidermal onion cells.

DTh2C.3 • 10:30

Extraction of Biophysical Parameters from Label-free Digital Holographic Phase Microscopy Images for Cell Culture Quality Control, Lena Kastl¹, Michael Isbach¹, Dieter Dirksen¹, Jürgen Schnekenburger¹, Björn Kemper¹; ¹Univ. of Muenster, Germany. We demonstrate the extraction of biophysical parameter sets such as refractive index, volume and dry mass from label-free quantitative phase microscopy images for assessment of cell culture quality control.

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

Citron

Digital Holography &
3-D Imaging

Clementine

Adaptive Optics: Methods, Analysis
and Applications

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09:00–09:45 Coffee Break with Exhibitors, Palms Foyer

09:45–11:15

CTh2D • Phase Retrieval

Presider: Seung-Whan Bahk; Univ. of Rochester, USA

CTh2D.1 • 09:45 **Invited**

Plenoptic imaging from intensity correlations, Francesco Vincenzo Pepe³, Francesco Di Lena¹, Aldo Mazzilli¹, Eitan Edrei², Augusto Garuccio¹, Giuliano Scarcelli², Milena D'Angelo¹; ¹Università degli Studi di Bari, Italy; ²Fischell Dept. of Bioengineering, Univ. of Maryland, USA; ³Sezione di Bari, INFN Istituto Nazionale di Fisica Nucleare, Italy. We demonstrate, theoretically and experimentally, the possibility to perform plenoptic imaging by measuring intensity correlations of light. Unlike standard plenoptic procedures, the technique we propose does not sacrifice spatial resolution to achieve directional resolution.

CTh2D.2 • 10:15

A new method for designing highly efficient metasurface devices: Local Phase Method, Liyi Hsu¹, Matthieu Dupre¹, Abdoulaye Ndao¹, Boubacar Kante¹; ¹Univ. of California San Diego, USA. We have proposed and developed a new and versatile approach named Local phase method to quantify the phase error of each element within a metasurface accounting for the near-field coupling. This method can improve the performance of any devices based on metasurfaces.

CTh2D.3 • 10:30

Novel Optimizations for Phase Retrieval, Ashish Tripathi¹, John Barber¹, Richard Sandberg¹; ¹Los Alamos National Lab, USA. We demonstrate improvements in iterative phase retrieval algorithms for coherent diffractive imaging using novel non-convex and nonlinear numerical optimization techniques. We incorporate all prior knowledge of the experimental geometry and sample physics.

09:45–11:45

DTh2E • Advances in DH Techniques 2

Presider: Yoshio Hayasaki; Utsunomiya Univ., Japan

DTh2E.1 • 09:45 **Invited**

Near-field imaging using digital holographic interferometry with total internal reflection and surface plasma resonance, Jianlin Zhao¹, Jiwei Zhang¹; ¹Northwestern Polytechnical Univ., China. Near-field refractive index and film thickness on prism or metal surface can be determined, by measuring the complex amplitude distributions of reflected light in total internal reflection and surface plasma resonance using digital holographic interferometry.

DTh2E.2 • 10:15 **Invited**

Optical cryptography with biometrics and optical scanning holography, Aimin Yan¹, Zhijuan Hu¹, Peter Tsang², Ting-Chung Poon³; ¹Shanghai Normal Univ., China; ²City Univ. of HongKong, China; ³Virginia Tech, USA. In this invited talk, we will review optical cryptography with biometrics for multi-depth objects using optical scanning holography (OSH). We also focus on the discussion of key distribution.

09:45–11:30

OTH2F • AO Systems II

Presider: Szymon Gladysz; Fraunhofer Inst. IOSB, Germany

OTH2F.1 • 09:45 **Invited**

New Technologies for Astronomical Adaptive Optics, Donald T. Gavel¹; ¹Univ. of California Observatories, USA. In this presentation we discuss the technology advances that have enabled high performance adaptive optics for astronomy and discuss prospects for the future.

OTH2F.2 • 10:15 **Invited**

Adaptive Optics in Optical Communication Systems, Alan E. Willner¹; ¹Univ. of Southern California, USA. Adaptive optics plays an important role in combatting deleterious effects in free-space optical communication systems. This paper will describe issues related to the mitigation of data-degrading effects (e.g., atmospheric turbulence) for single and multiple beam systems.

Sunset/Fleming

Applied Industrial Optics

Siesta/Biscayne

Imaging Systems and Applications

Cedar/Marathon

Digital Holography & 3-D Imaging

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

ATH2A • Another Day, Another Detector—Continued

ATH2A.3 • 10:45

UV-Controlled Triboelectric Formation of Two-Beam Interference Pattern with Nano-Volcano Array, Jaeyoun Kim¹, Qiang Li¹; ¹Iowa State Univ., USA. Adding sub-structures to sub-micron-scale to polymer surface patterned through two-beam interference has been deemed highly challenging. Using replica molding, triboelectric effect, and electrohydrodynamic lithography, we achieve decoration of sinusoidally corrugated NOA73 surface with nanoscale volcano arrays.

ATH2A.4 • 11:00 **Invited**

High-performance Optoelectronic and Nanophotonic Devices Enabled by Ultra-thin, Smooth, and Low-loss Doped Silver, Cheng Zhang¹, Henri J. Lezec¹, Wenqi Zhu¹, Amit Agrawal¹; ¹NIST, USA. We present a new plasmonic material termed 'doped Ag', and its applications in various optoelectronic and nanophotonic devices with improved performance, including organic solar cells, polymer light emitting diodes, hyperbolic metamaterials, and plasmonic interconnects.

ITh2B • Sensors & Optics—Continued

ITh2B.3 • 10:45

2-Terminal Organic FPA Pixel Design for Curved Image Sensors, Zhao Ma¹, Christopher K. Renshaw^{1,2}; ¹CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA; ²Physics, Univ. of Central Florida, USA. We demonstrate a novel 2-terminal pixel design to enable fabrication of curved image sensors using organic semiconductors. The vertically-stacked anti-polar diode (VAD) pixel incorporates a blocking diode to provide a low-current and light-independent OFF state under forward bias.

ITh2B.4 • 11:00 **Invited**

Engineered Materials for Next Generation EO/IR Sensors, Clara Rivero-Baleine¹, Andrew Kirk¹, Megan Driggers¹, Johann Veras¹, Erwan Baleine¹, Kathleen Richardson², Myungkoo Kang², Anupama Yadav², Juejun Hu³, Tian Gu³, Yifei Zhang³, Mikhail Y. Shalaginov³, Ray Hilton⁴, Tom Loretz³; ¹Lockheed Martin, USA; ²Univ. of Central Florida, USA; ³MIT, USA; ⁴Amorphous Materials Inc., USA. Next generation Electro-Optical / Infrared (EO/IR) sensors will require innovative materials that can be engineered to serve complex optical functions. Here we highlight how these properties can be tailored to enable next generation EO/IR sensors.

ITh2B.5 • 11:30

Infrared Monolithic Double Diffractive Kinoform Doublet on a Planar Substrate - Coupled Design Model, Kim W. Larsen¹; ¹NVESD, US ARMY RDECOM CERDEC, USA. Monolithic double diffractive doublets on a planar substrate for infrared color correction are modeled using a coupled physical and phase model in a ray-trace program for optical design with custom coupling and analysis macros.

DTh2C • Digital Holographic Microscopy—Continued

DTh2C.4 • 10:45

Full compensation of quantitative phase images of digital holographic microscopy using GPU, Carlos A. Trujillo¹, Raúl Castañeda¹, Pablo Piedrahita-Quintero¹, Jorge Garcia-Sucerquia¹; ¹Univ Nacional de Colombia Medellin, Colombia. A GPU-accelerated method that fully compensates the quantitative phase measurements in off-axis digital holographic microscopy (DHM) is presented. The algorithm has been validated on DHM holograms of biological samples running at attractive processing times.

DTh2C.5 • 11:00

Compact and flexible digital holographic microscopy based on wavefront segmentation, Liangcai Cao¹, Wenhui Zhang¹, Hua Zhang¹, hao zhang¹, Guofan Jin¹; ¹Tsinghua Univ., China. A compact digital holographic microscopy with high stability and high flexibility based on wavefront segmentation is proposed. The system only consists of a few optical elements without strict alignments, making it robust and easy-to-implement.

DTh2C.6 • 11:15

Spatial Analysis of Osteocytes Membrane Fluctuations under LMHF Vibration Using Digital Holographic Microscopy, Cao Runyu¹, Xiaosu Yi¹, Wen Xiao¹, Feng Pan¹; ¹Beihang Univ., China. We measured membrane fluctuations of osteocytes under vibration caused by sound wave using digital holographic microscopy (DHM). Distinct differences in frequency spectrum were found between cells and backgrounds.

DTh2C.7 • 11:30

Wavefront Reconstruction in Holographic Scanning Microscopy, Yuri Zakharov¹, Mariya Muravyeva², Umar Khan¹, Lei Zhang¹, Vladimir Turzhitsky¹, Edward Vitkin¹, Irving Itzkan¹, Le Qiu¹, Lev Perelman¹; ¹Harvard Univ., USA; ²Lobachevsky Nizhny Novgorod Univ., Russia. A reconstruction algorithm for holographic scanning microscopy should take into account scanning-associated phase shifts. Here we present the stable, not prone to noise, algorithm which does not require additional recording of the object wave intensity.

11:45–13:30 Lunch on your Own

13:00–18:00 Tour of Laser Propagation Facilities at Kennedy Space Center (Extra fee and advanced registration required.)

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

Citron

Digital Holography &
3-D Imaging

Clementine

Adaptive Optics: Methods, Analysis
and Applications

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CTh2D • Phase Retrieval—Continued

CTh2D.4 • 10:45

Phase Retrieval Based on Wave Modulation, Xingchen Pan¹, Cheng Liu¹, Jianqiang Zhu¹; ¹*Shanghai Inst of Optics and Fine Mech, China*. Two novel single-shot phase retrieval algorithms based on the modulation of random aperture, which is insensitive to wavelength, and continuous phase plate, which provides weak modulation, are proposed and demonstrated by experiments respectively.

CTh2D.5 • 11:00

Enhanced Phase Retrieval using Quantum Illumination, Yaotian Wang¹, Hugo Defienne¹, Matthew Reichert¹, Jason W. Fleischer¹; ¹*Electrical Engineering, Princeton Univ., USA*. We use quantum illumination to improve classical phase retrieval algorithm. The quantum-assisted algorithm shows improved performance over the classical methods.

DTh2E • Advances in DH Techniques 2—Continued

DTh2E.3 • 10:45

Six-Pack Off-Axis Holographic Multiplexing, Natan T. Shaked¹, Gili Dardikman¹, Moran Rubin¹; ¹*Tel-Aviv Univ., Israel*. We present six-pack off-axis holography, in which six off-axis holograms are compressed into a single multiplexed off-axis hologram without loss of magnification or resolution, allowing more than 50% improvement in the camera spatial bandwidth consumption.

DTh2E.4 • 11:00

Fourier Transform Holography at the Wavelength Limit, Getnet K. Tadesse^{1,2}, Wilhelm Eschen², Robert Klas^{1,2}, Vinzenz Hilbert², Detlef Schelle², Anne Nathanael², Matthias Zilk², Michael Steinert², Frank Schrepel², Thomas Pertsch², Andreas Tünnermann^{2,3}, Jens Limpert^{1,2}, Jan Rothhardt^{1,2}; ¹*Helmholtz Inst. Jena, Germany*; ²*Inst. of Applied Physics, Friedrich-Schiller-Univ. Jena, Germany*; ³*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany*. We present a table-top Fourier transform holography experiment that achieved a record-high resolution of 34 nm. By employing phase retrieval techniques, the resolution was improved to 23 nm (<1.3 λ) limited by wave-guiding effects.

DTh2E.5 • 11:15

Crystalline Silicon (c-Si) Metasurface Holograms in the Visible Range, Augusto Martins¹, JUntao Li^{2,3}, Achilles F. Mota¹, Yin Wang², Luiz G. Neto¹, João Paulo P. do Carmo¹, Fernando Teixeira⁴, Emiliano R. Martins¹, Ben-Hur V. Borges¹; ¹*Dept. of Electrical Engineering, Univ. of São Paulo, Brazil*; ²*State Key Lab of Optoelectronic Materials & Technologies, Univ. of Sun Yat-Sen, China*; ³*School of Physics, Univ. of Sun Yat-Sen, China*; ⁴*Dept. of Electrical and Computer Engineering, Ohio State Univ., USA*. This paper presents the first experimental demonstration of c-Si metasurface holograms operating with good quality in the visible range. The measured transmission (diffraction) efficiencies are as high as 47.4% (30%) at the designed wavelength of 532nm.

DTh2E.6 • 11:30

Holographic Phase Masks for Generation of Vortex Beams Recorded in Photo-Thermo-Refractive Glass, Fedor Kompan¹, David Guacaneme¹, Zachary Labossiere¹, Duc-Quy Nguyen¹, Ivan Divliansky¹, Leonid Glebov¹; ¹*CREOL, Univ. of Central Florida, USA*. Optical angular momentum (OAM) beams have been actively studied due to wide range of applications including micromanipulation and telecommunications. We present a method for producing high quality robust phase masks for generation of OAM beams.

OTh2F • AO Systems II—Continued

OTh2F.3 • 10:45 Invited

Astronomical Adaptive Optics: Challenges and Pathways, Katie M. Morzinski¹; ¹*Center for Adaptive Optics, USA*. General-purpose astronomical AO systems are giving way to custom-built instruments designed for specific applications. I will describe how myriad science cases call for different AO technologies, and discuss challenges from technology development to telescope environment.

OTh2F.4 • 11:15

The ExoLife Finder (ELF) Telescope: New Adaptive Optics and Hybrid Dynamic Live-Optical Surfaces Strategies., Gil Moretto¹, Jeff Kuhn², Maud Langlois¹, Michel Tallon¹, Jean-Fabien Capsal³, David Audigier³, Krittadi Thetraphi³, Mike Gedig³, Andrew Norton⁴, Svetlana V. Berdyugina⁵, David Halliday⁵; ¹*CRAI/CNRS, France*; ²*IFA, Univ. of Hawaii, USA*; ³*LGEF, INSA Lyon, France*; ⁴*Lick Observatory, Univ. of California, USA*; ⁵*Dynamic Structures Ltd., Canada*; ⁶*Kiepenheuer Inst. für Sonnenphysik, Germany*. The exponential growth in exoplanets studies and related science such as detecting life and even civilizations on Earth-like planets requires high angular resolution and high-contrast observations. Such appealing sciences cases are a powerful reason for developing a dedicated high contrast telescope concept – The ExoLife Finder (ELF) Telescope. Here we describe ELF's overall optical, AO and mirrors concepts.

11:45–13:30 Lunch on your Own

13:00–18:00 Tour of Laser Propagation Facilities at Kennedy Space Center (Extra fee and advanced registration required.)

Sunset/Fleming

Joint Applied Industrial Optics/
Computational Optical Sensing
and Imaging

13:30–15:15

**JTh3A • Ptychography, It's
Complex (AIO/COSI)**

*Presider: Jaeyoun Kim; Iowa State
Univ., USA*

JTh3A.1 • 13:30 **Invited**

Fourier Ptychographic Method for High Resolution and Wide Field of View Retinal Imaging, Changhui Yang¹, Jaebum Chung¹; ¹California Inst. of Technology, USA. We present a high-resolution retinal imaging system capable of computationally correcting for the eye's aberration to resolve photoreceptors at cellular level. It is based on a novel adaptation of Fourier ptychographic algorithm and coded apertures.

JTh3A.2 • 14:00

Multiplexed Single-Shot Ptychography, Bing Kuan Chen¹, Pavel Sidorenko¹, Oren Lahav¹, Or Peleg¹, Oren Cohen¹; ¹Technion, Israel. We propose and demonstrate single-shot polarization-resolved ptychographic microscope and ultrahigh-speed ptychographic microscope. They are based on the application of mixed-state reconstruction algorithm in single-shot ptychography (the ptychographic data is recorded in a single CCD exposure).

Siesta/Biscayne

Joint Computational Optical
Sensing and Imaging/
Digital Holography & 3-D Imaging

13:30–15:00

**JTh3B • Holographic Microscopy
(COSI/DH)**

*Presider: Abbie Watnik; US Naval
Research Lab, USA*

JTh3B.1 • 13:30

Sampling and processing for multiple scattering in inline compressive holography, Waleed Tahir², Ulugbek S. Kamilov¹, Lei Tian²; ¹Washington Univ. in St. Louis, USA; ²Boston Univ., USA. Inline holography is approached from a computational perspective by incorporating a nonlinear forward model based on the iterative Born approximation (IBA). Sampling and its effects on multiple scattering computations are discussed.

JTh3B.2 • 13:45

Multi-constrained Phase Retrieval for Lens-Free Inline holographic microscopy, Xia Hua¹, Cheng Yang¹, Beibei Xu², Feng Yan¹, Xun Cao¹; ¹School of Electronic Science and Engineering, Nanjing Univ., China; ²College of Engineering and Applied Sciences, Nanjing Univ., China. High-resolution wide-field microscopy plays an essential role in various fields. A multi-constrained phase retrieval algorithm is presented for lens-free inline holographic microscopy. Experimental results shown that the proposed method could effectively eliminate twin image noise.

JTh3B.3 • 14:00

Resolution Enhancement in Digital Holographic Microscopy under Grating-based Illumination, Shaohui Li¹, Shaotong Feng¹, Jun Ma², Qingyu Ma¹, Caojin Yuan¹; ¹Nanjing Normal Univ., China; ²Nanjing Univ. of Science and Technology, China. We present a single-shot resolution enhancement method under grating-based illumination in the digital holographic microscopy. The recorded information without crosstalk is separated by multiplexing techniques. The method is verified by the experiments.

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

13:30–15:30

**CTh3C • Imaging through
Aberrations, Structured
Illumination & Super Resolution**

*Presider: Prasanna Rangarajan;
Southern Methodist University, USA*

CTh3C.1 • 13:30

Temporal Super-resolution Full Waveform LiDAR, Jun Ke¹, Edmund Y. Lam²; ¹Beijing Inst. of Technology, China; ²The Univ. of Hong Kong, Hong Kong. In full waveform LiDAR, system ranging resolution is limited by the pulse width of a laser source, and the bandwidth of a detector and an A/D. To overcome the limitation, temporal super-resolution is studied in this paper.

CTh3C.2 • 13:45

Super-Resolution Imaging Based on Spectral Dimensional Information, Zhishen Tong^{1,2}, Jian Wang³, Zengfeng Huang³, Zhentao Liu¹, Chenyu Hu^{1,2}, Xia Shen¹, Jianrong Wu¹, shensheng han¹, Enrong Li¹; ¹Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; ²Univ. of Chinese Academy of Sciences, China; ³School of Data Science, Fudan Univ., China. A method based on spectral dimensional information is proposed to realize the super-resolution imaging. Numerical simulation shows that performance with spectral constraint is better than no spectral constraint under low signal-to-noise ratio.

CTh3C.3 • 14:00

Remote Sensing of Photoplethysmogram using Multi Spot Illumination, Nisan Ozana¹, Hadar Genish³, Ran Califa³, Ariel Schwarz¹, Sagi Polani², Javier Garcia², Zeev Zalevsky¹; ¹Bar Ilan Univ., Israel; ²Universitat de València, Spain; ³ContinUse Biometrics Ltd., Israel. The ability to remotely extract Photoplethysmogram (PPG) signals is of great interest. A novel approach to overcome motion related noise, based on a multi spot pattern was experimentally demonstrated. Improvement of PPG signal is presented.

Citron

Digital Holography &
3-D Imaging

13:30–15:30

**DTh3D • Integral Imaging and
Holographic Displays**

*Presider: Liangcai Cao; Tsinghua
Univ., China*

DTh3D.1 • 13:30 **Tutorial**

Full Color Holographic Printing Techniques and Fast Digital Hologram Generation Methods, Hoonjong Kang¹; ¹Korea Electronics Technology Inst., South Korea. Abstract to be provided.

Clementine

Adaptive Optics: Methods,
Analysis and Applications

13:30–15:15

OTH3E • Control & Simulations

*Presider: Caroline Kulcsar; Institut
d'Optique Graduate School, France*

OTH3E.1 • 13:30 **Invited**

Advanced Control Algorithms and Control Structures for Adaptive Optics Systems, Michael Böhm¹, Martin Glück¹, Jörg-Uwe Pott², Kevin Schmidt¹, Oliver Sawodny¹; ¹Inst. for System Dynamics, Univ. of Stuttgart, Germany; ²Max-Planck-Inst. for Astronomy, Germany. Advanced control structures for adaptive optics in astronomy will be explained briefly and simulations along with LBT experimental data illustrating its benefits will be shown. A different application for model-based control of DMs is sketched.

OTH3E.2 • 14:00

Power-in-the-Bucket and Stoke Efficiency with Woofer-Tweeter Deformable Mirrors and Image Sharpening, Dennis F. Gardner¹, Abbie T. Watnik¹, Mark F. Spencer²; ¹Naval Research Lab, USA; ²U.S. Air Force Research Lab, USA. Various basis sets are used in an image sharpening algorithm to command dual deformable mirrors in simulation. The power-in-the-bucket measurements and mirror stroke efficiency are used as the performance metrics to compare the basis sets.

Sunset/Fleming

Joint Applied Industrial Optics/
Computational Optical Sensing
and Imaging

JTh3A • Ptychography, It's Complex (AIO/COSI)—Continued

JTh3A.3 • 14:15

Fourier Ptychography Using Low-Cost Bayer Color Sensors, Tomas Aidukas¹, Andrew R. Harvey¹, Pavan Konda¹; ¹Univ. of Glasgow, UK. We report a Fourier ptychography reconstruction that enabled the use of low-cost Bayer-filtered color cameras. Using 3D-printing, consumer electronics and robust calibration we demonstrated a microscope capable of capturing sub-micron resolution 25-megapixel images under \$150.

JTh3A.4 • 14:30

High-resolution (diffraction limit) single-shot ptychography for ultra-high-speed microscopy, Gil Ilan Haham¹, Or Peleg¹, Pavel Sidorenko², Oren Cohen¹; ¹Technion, Israel; ²Cornell, USA. We propose a module that upgrades a conventional single-shot microscope into a single-shot ptychographic microscope, without spoiling its optical performances. This approach paves the way to single-frame or ultrahigh-speed, high-resolution microscopes of complex-valued objects.

JTh3A.5 • 14:45

Fast light source misalignment correction of Fourier ptychographic microscopy, Ao Zhou^{1,2}, Wei Wang³, Ni Chen¹, Guohai Situ¹; ¹Shanghai Inst. of Optics and Fine Mechanics, China; ²Univ. of Chinese Academy of Sciences, China; ³National Univ. of Singapore, Singapore. We propose an effective method to correct the LED misalignment in Fourier ptychographic microscopy. The experimental results show the proposed method is faster and more robust than the other simulated annealing based methods.

Siesta/Biscayne

Joint Computational Optical
Sensing and Imaging/
Digital Holography & 3-D Imaging

JTh3B • Holographic Microscopy (COSI/DH)—Continued

JTh3B.4 • 14:15

The effects of cytokeratin knock-out on breast cancer cell phase features assessed with telecentric digital holographic microscopy (DHM) and machine learning, Van Lam¹, George Nehmetallah¹, Byung Min Chung¹, Christopher Raub¹; ¹Catholic Univ. of America, USA. A telecentric DHM system and a support vector machine-based classifier were developed to investigate the effects of cytokeratin 19 knockout on the morphology and phase features of MDA-MB-231 breast cancer cells.

JTh3B.5 • 14:30

Phase aberration compensation in digital holographic microscopy using regression analysis, Zhenbo Ren¹, Zhimin Xu², Edmund Y. Lam¹; ¹Univ. of Hong Kong, Hong Kong; ²SharpSight Limited, Hong Kong, Hong Kong. In digital holographic microscopy, phase aberration, including the tilt and quadratic aberration, affects the visualization and measurement of the quantitative phase of the object. Here we propose a regression-based method to compensate the phase aberration.

JTh3B.6 • 14:45

Total aberrations compensation for digital holographic microscopy with geometrical transformations, Wenqi He¹, Dingnan Deng¹, Weijuan Qu², Xiaoli Liu¹, Xiang Peng¹; ¹College of Optoelectronic Engineering, China; ²Ngee Ann polytechnic, Singapore. We propose a total aberrations compensation method for digital holographic microscopy with geometrical transformations. The rotation transformation with 180° and reflection transformation can be used for compensating the off-axis tilt and parabolic phase aberration, respectively.

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

CTh3C • Imaging through Aberrations, Structured Illumination & Super Resolution— Continued

CTh3C.4 • 14:15

Enlarged Field of View Scattering Imaging Using Speckle Autocorrelation, Rui Yuan¹, Yuegang Fu¹, Jianhong Zhou¹; ¹Changchun Univ. of Science and Tech, China. Large-field imaging through strongly tissues still presents a challenge. We propose a method to enlarge the field of view using digital micromirror device. With speckle autocorrelation and phase retrieval algorithm, the method is practical.

CTh3C.5 • 14:30

Mitigating metalens aberrations via computational imaging, Shane A. Colburn¹, Arka Majumdar¹; ¹Univ. of Washington, USA. We design hybrid imagers where together metalenses and deconvolution improve image quality while minimizing form factor. We aim to mitigate chromatic and geometric aberrations by designing wavelength-invariant point spread functions and characterizing their spatial variance.

Citron

Digital Holography &
3-D Imaging

DTh3D • Integral Imaging and Holographic Displays—Continued

DTh3D.2 • 14:15

Color Image Generation by Multi-Channel Viewing-Zone Scanning Holography, Yasuhiro Takaki¹, Mitsuki Nakaoka¹, Keisuke Hieda²; ¹Tokyo Univ. of Agriculture and Technology, Japan; ²HIOKI EE CORPORATION, Japan. The multi-channel viewing-zone scanning holography, which provides large screen size and viewing zone, is modified to generate color images. The technique to adjust colors among multiple screens using the RGB color luminance meter is developed.

DTh3D.3 • 14:30

A method to enhance the depth range of an integral imaging system using a geometric phase lens, Minyoung Park¹, Hee-Jin Choi¹; ¹Sejong Univ., South Korea. In this paper, we propose a method to provide 3D image with enhanced depth range by integrating them in two central depth planes using a geometric phase lens.

DTh3D.4 • 14:45

Miniature Solid-State Holographic Display with Cloud Computing, Michal Makowski¹, Adam Kowalczyk¹, Izabela Ducin¹, Karol Kakarenko¹, Jaroslaw Suszek¹, Marcin Bieda¹, Paula Kochanska¹; ¹Faculty of Physics, Warsaw Univ. of Technology, Poland. A robust, miniaturized, color, lens-less holographic projection display without moving parts is presented, which offers high efficiency of 35-100 lm/W, small volume below 5 cm³ and cloud computing capability for built-in projectors of future smartphones.

Clementine

Adaptive Optics: Methods,
Analysis and Applications

OTh3E • Control & Simulations— Continued

OTh3E.3 • 14:15

FPGA Implementations of Low Latency Centroiding Algorithms for Adaptive Optics, Manuel Cegarra Polo¹, Fanpeng Kong¹, Andrew Lambert¹; ¹UNSW Adfa, Australia. We describe two innovative low latency centroiding algorithms implemented in an FPGA, exploiting the parallel processing features of these devices, and showing low values in latency and real estate, which eases their integration with complete adaptive optics systems.

OTh3E.4 • 14:30

Adaptive Optic Wavefront Correction using a Convolutional Neural Network, Andrew Norton¹, Noah Toyonaga¹, Bruce Macintosh¹, Steven Chu²; ¹Kavli Inst. for Particle Astrophysics and Cosmology, Stanford Univ., USA; ²Dept. of Molecular and Cellular Physiology, Stanford Univ., USA. We show how using a state-of-the-art deep learning convolutional neural network allows for measuring and correcting phase aberrations in astronomy and biological adaptive optic applications.

OTh3E.5 • 14:45

Some simple results about adaptive optics performance evaluation in 'replay mode', Caroline Kulcsar¹, Henri-François Raynaud¹, Remy Juvenal^{1,2}, Jean-Marc Conan²; ¹Laboratoire Charles Fabry, CNRS-Institut d'Optique France; ²ONERA, The French Aerospace Lab, France. Replay mode simulations enable to evaluate AO control performance (residual variance) using on-sky telemetry. This paper proposes simple procedures to remove estimation bias and to evaluate the impact of on-sky measurement noise propagation.

Sunset/Fleming

Joint Applied Industrial Optics/
Computational Optical Sensing
and Imaging

**JTh3A • Ptychography, It's
Complex (AIO/COSI)—Continued**

JTh3A.6 • 15:00

A deep-learning approach for high-speed Fourier ptychographic microscopy, Thanh Nguyen¹, Yujia Xue², Yunzhe Li², Waleed Tahir², Lei Tian², George Nehmetallah¹; ¹Catholic Univ. of America, USA; ²Dept. of Electrical and Computer Engineering, Boston Univ., USA. We demonstrate a new convolutional neural network architecture to perform Fourier ptychographic Microscopy (FPM) reconstruction, which achieves high-resolution phase recovery with considerably less data than standard FPM.

Siesta/Biscayne

Joint Computational Optical
Sensing and Imaging/
Digital Holography & 3-D Imaging

**JTh3B • Holographic Microscopy
(COSI/DH)—Continued**

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

**CTh3C • Imaging through
Aberrations, Structured
Illumination & Super Resolution—
Continued**

Citron

Digital Holography &
3-D Imaging

**DTh3D • Integral Imaging and
Holographic Displays—Continued**

DTh3D.5 • 15:00

Simple geometrical calibration procedure for a projection-type holographic light-field display, Tomoya Nakamura^{1,2}, Masahiro Yamaguchi¹; ¹School of Engineering, Tokyo Inst. of Technology, Japan; ²PRESTO, Japan Science and Technology Agency, Japan. Holographic light-field display is a 3D display with a holographic optical element. This paper reports a simple calibration procedure for the matrix-type holographic light-field display, and demonstrate the calibration and 3D imaging.

DTh3D.6 • 15:15

Bandwidth utilization improvement methods of Coarse Integral Holographic video displays, Jin Li¹, Quinn Smithwick², Daping Chu¹; ¹Univ. of Cambridge, UK; ²Disney Research, USA. This paper introduces two methods to improve the bandwidth utilization in the Coarse Integral Holographic Display architecture, achieving doubled horizontal field of view and fully utilized bandwidth for the spatial light modulator in use.

Clementine

Adaptive Optics: Methods,
Analysis and Applications

**OTh3E • Control & Simulations—
Continued**

OTh3E.6 • 15:00

Numerical Simulation of Atmospheric Tomography with Plenoptic Camera, Cheng Li¹, He Liu¹, Pin Lv¹, Yu Ning²; ¹Inst. of Software Chinese Academy of, China; ²College of Optoelectronic Science and Engineering, National Univ. of Defense Technology, China. This paper propose that one plenoptic camera has potential to replace several Shack-Hartmann WFS in MCAO, in which way it can rebuild turbulence layers by three NGS or LGS at different heights with lightfield tomography.

15:30–16:00 Coffee Break with Exhibitors, Palms Foyer

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

16:00–17:45

CTh4A • Quantum Computational Imaging

Presider: Andy Harvey; University of Glasgow, UK

CTh4A.1 • 16:00

Binarization threshold optimization of ghost imaging, Dongyue Yang¹, Junhui Li², Guohua Wu¹, Bin Luo², Longfei Yin¹, Hong Guo³; ¹School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China; ²State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China; ³State Key Lab of Advanced Optical Communication Systems and Networks, Peking Univ., China. Quantized discrete sampling, in particular, binarization decreases image quality of ghost imaging. Performance optimizing binarization threshold can approach that without quantization. Median is more likely to be the optimal threshold than the first quantization level.

CTh4A.2 • 16:15

Ghost Imaging With Gram-Schmidt Orthogonalization, Pengqi Yin¹, Longfei Yin¹, Bin Luo², Guohua Wu¹, Hong Guo³; ¹School of Electronic Engineering, Beijing Univ. of Posts and Telecommunications, China; ²State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China; ³School of Electronics Engineering and Computer Science, Peking Univ., China. We orthonormalize the reference patterns those are generated by a pseudo-thermal source and calculate new bucket detector responses. The obtained image quality by new orthonormal references and bucket signals is improved.

CTh4A.3 • 16:30

Comparison between ghost imaging and traditional active optical imaging, WeiTao Liu¹; ¹Dept. of Physics, College of Liberal Arts and Sciences, National Univ. of Defense Technology, China. Considering spatial resolution, robustness, detection sensitivity, data acquisition, we made comparison on features of imaging methods between ghost imaging and traditional active optical imaging, under the same experimental conditions.

CTh4A.4 • 16:45

Demonstration of computational temporal ghost imaging: detecting fast signals beyond bandwidth of detectors, Yao-Kun Xu¹, WeiTao Liu¹; ¹Natl Univ Def Tech, China. The signal with time scale of 50ns can be reconstructed via a 1kHz bandwidth detector based on computational temporal ghost imaging. The performance of our technique using detectors with different bandwidths is also discussed.

CTh4A.5 • 17:00

Imaging the Joint Probability Distribution of Spatially Entangled Photon Pairs with a Camera, Matthew Reichert¹, Hugo Defienne¹, Jason W. Fleischer¹; ¹Princeton Univ., USA. We present massively parallel coincidence counting of entangled photon pairs by measuring coincidences between all pairs of pixels in a single-photon-sensitive camera, including the case where both entangled photons arrive in the same pixel.

Citron

Digital Holography &
3-D Imaging

16:00–18:00

DTh4B • System Design and Data Processing in DH

Presider: Pascal Picart; LAUM CNRS Université du Maine, France

DTh4B.1 • 16:00 **Invited**

Underwater Digital Holography for Particles Research, Victor V. Dyomin¹; ¹Tomsk State Univ., Russia. Methods for extracting information from underwater digital particle holograms are suggested and tested. A set of DHC-sensors adapted for various purposes is described. Results of hardware and software approbation during the Kara Sea mission are presented.

DTh4B.2 • 16:30

Refocus Criterion Based on the Phase in the Fourier Domain for Automatically Refocusing in Multispectral Digital Holographic Microscopy: Accuracy and Dependency Study, Jerome Dohet-Eraly², Catherine Yourassowsky¹, Timothy D. Wilkinson², Frank Dubois¹; ¹Universite libre de Bruxelles, Belgium; ²Univ. of Cambridge, UK. The fast autofocus criterion using the phase in the Fourier domain, suitable for digital holographic microscopy when the complex field is known for at least two distinct wavelengths, is deeply investigated, which allows finer adjustment.

DTh4B.3 • 16:45

Normalization method for generalized phase-shifting digital holography, Nobukazu Yoshikawa¹, Syouma Namiki¹, Atsushi Uoya¹; ¹Saitama Univ., Japan. We propose a normalization method for generalized phase-shifting digital holography. We present the norm approximation for phase-shifted holograms using the statistical property of the random phase distribution in the Fresnel diffraction field.

DTh4B.4 • 17:00

Multi-look approaches for phase map de-noising in digital Fresnel holography: comparative analysis, Silvio Montresor¹, Pascale Memmolo², Vittorio Bianco², Pascal Picart^{1,3}, Pietro Ferraro²; ¹LAUM CNRS Le Mans Université, France; ²ISASI-CNR, Italy; ³ENSIM, France. This paper presents a comparative study of multi-look approaches for de-noising phase maps from digital holography experiments. The results demonstrate that the two-dimensional windowed Fourier transform filtering exhibits the best performance in all cases.

Clementine

Adaptive Optics: Methods, Analysis
and Applications

16:00–18:00

OTh4C • Adaptive Optics Systems for the Eye

Presider: Julian Christou; Large Binocular Telescope Observatory

OTh4C.1 • 16:00 **Invited**

Adaptive Optics and Full-field OCT: the expected gain, Claude A. Boccara¹, Peng C. Xiao¹, Viatcheslav Mazlin¹, Jules Scholler¹, Mathias Fink¹; ¹Institut Langevin, France. Full-field Optical Coherence Tomography (FFOCT) offers aberration independent resolution. This property is particularly useful for retinal imaging nevertheless where we have to face signal reduction that often impose adaptive optics (AO).

OTh4C.2 • 16:30 **Invited**

Adaptive-Optics based visual simulators: from on-bench to wearable devices, Susana Marcos¹, Maria Vinas¹, Carlos Dorronsoro¹, Lucie Sawides^{2,1}, Enrique Gamba^{2,1}, Clara Benedi¹, Sara ElAissati¹; ¹Consejo Sup Investigaciones Cientificas, Spain; ²EyesVision, Spain. Adaptive Optics have become useful tools for basic research in visual psychophysics and neuroscience, in the development of new optical corrections, and in the clinic allowing patients to experience prospective corrections prior to implantation.

OTh4C.3 • 17:00 **Invited**

Adaptive Optics Systems for Vision Science, Enrique-Josua Fernandez¹; ¹Universidad de Murcia, Spain. Adaptive optics contributes to Vision Science in a two-fold approach: to better image the fundus of the eye, and to study how optics affects our vision. This work will mainly focus on the latter.

Orange/Lemon/Lime

Computational Optical Sensing
and Imaging

CTh4A • Quantum Computational Imaging—Continued

CTh4A.6 • 17:15

Optimization of light field fluctuation patterns in ghost imaging by mutual coherence minimization based on dictionary learning, Chenyu Hu^{1,2}, Jian Wang³, Zengfeng Huang³, Zhishen Tong^{1,2}, Liu S. Ying^{1,2}, Shuang Ma^{1,2}, Zhentao Liu¹, Shensheng Han^{1,2}; ¹Key Lab for Quantum Optics and Center for Cold Atom Physics of CAS, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; ²Univ. of Chinese Academy of Sciences, China; ³School of Data Science, Fudan Univ., China. We propose a scheme of optimization in ghost imaging by minimizing the mutual coherence between measurement matrix and an overcomplete dictionary. Simulation results show the effectiveness of the optimization.

CTh4A.7 • 17:30

Characterizing the optical memory effect using quantum illumination, Hugo Defienne¹, Matthew Reichert¹, Jason W. Fleischer¹; ¹Electrical engineering, Princeton Univ., USA. We introduce a general adaptive quantum optics approach to control spatial entanglement and use it to characterize the optical memory effect of a thin scattering medium.

Citron

Digital Holography &
3-D Imaging

DTh4B • System Design and Data Processing in DH—Continued

DTh4B.5 • 17:15

Fringe Projection Profilometry Performed with a Light Field Camera, Xiaoli Liu¹, Zewei Cai¹, Xiang Peng¹, Bruce Z Gao²; ¹Shenzhen Univ., China; ²Dept. of Bioengineering, Clemson Univ., USA. A method of fringe projection profilometry combined with light field camera recording is introduced to achieve high dynamic range 3D imaging. The modulated fringe phases can be detected from multiple directions with light field camera. And employing a novel ray-based calibration approach, phase-height mapping coefficients and height coordinates along each ray direction can be accurately determined independently. The experimental results illuminate that this multidirectional depth estimation can achieve high dynamic range 3D imaging effectively.

DTh4B.6 • 17:30

A Fast Finite Difference Solver for Digital Holographic Based-Transport of Intensity Equation, Honbo Zhang¹, Partha P. Banerjee¹, Ting-Chung Poon², Wen-Jing Zhou³, Lin Wang², Ying Liu², Qihao Song²; ¹Dept. of Electro-Optics and Photonics, Univ. of Dayton, USA; ²Electrical and Computer Engineering, Virginia Tech, USA; ³Dept. of Precision Mechanical Engineering, Shanghai Univ., China; ⁴Computer and Information Sciences, Virginia Military Inst., USA. Transport of intensity, useful for image phase retrieval, requires multiple intensity recordings along the propagation direction. We propose an efficient and accurate finite-difference TIE solver using a single recorded digital hologram for unwrapped phase reconstruction.

DTh4B.7 • 17:45

Holographic Camera Development by Incoherent Digital Holography, Myung Kim¹; ¹Univ. of South Florida, USA. Three-dimensional imaging holographic camera is being developed based on the principles of self-interference incoherent digital holography. Using a simple optical arrangement and numerical processing, 3D scenes are captured with the ability to numerically refocus to any distance within the scene. We report the progress and current status of the development as well as potential issues.

Clementine

Adaptive Optics: Methods, Analysis
and Applications

OTh4C • Adaptive Optics Systems for the Eye—Continued

OTh4C.4 • 17:30 **Invited**

Adaptive optics for retinal imaging and new prospects in Flood-Illumination Ophthalmoscopy, Serge Meimon¹, Elena gofas-salas¹, pedro mece², Cyril Petit¹, Kate Grieve³, Laurent Mugnier¹, José-Alain Sahel³, Michel Paques³; ¹ONERA - The french aerospace lab, France; ²Quantel Médical, France; ³Vision Inst., Quinze-Vingts National Ophthalmology Hospital, Paris, France., France. The retina is the only optically accessible neurovascular network in the human body. After a brief state of the art, the latest results obtained with our Adaptive Optics Flood-Illumination Ophthalmoscope will be presented.

Key to Authors and Presiders

A

A, Vijayakumar - DM3F.3, DM3F.4, DM3F.5
 Abeywickrema, Ujitha - DW3F.4
 Abouraddy, Ayman F.- MTu2D.3, MW5D.5
 Abramovich, Amir - 3M3G.7
 Agocs, Emil - AM3A.4
 Agrawal, Amit - Ath2A.4
 Ahar, Ayyoub - JTu4A.10
 Aharon, Avihai - 3M3G.7
 Ahmed, Hamza - OW3J.3
 Ahn, Hyeong-Hak - JTu4A.1
 Aides, Amit - PTu5I.1
 Aidukas, Tomas - JTh3A.3
 Ait Ameer, Kamel - DM5F.1
 Ajrouche, hassan - LTu2C.1
 Akbarian, Amir - CW3B.1
 Akers, Benjamin - PTu2I.7
 Akondi, Vyas - AW2A.1
 Akyon, Fatih C.- CTu5D.8
 Alam, Shahinur - JTu4A.2
 Alcock, Simon G.- OW2J.2
 Aldén, Marcus - LTu2C.2
 Alekseenko, Igor - DW3F.1
 Alexandre, Daniel - DW5F.5
 Alieva, Tatiana - DM2F.4, DTu5F.7, MM5D.4
 Allard, Lars - SM3H.4
 Allgeyer, Edward - JTu5B.4
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 Alonso, Miguel A.- MTu2D.5
 Altamar-Mercado, Hernando - JTu4A.19
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 Altuzarra, Charles - IM2B.3
 Andrews, Larry - PW3H.5
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 Arce, Gonzalo R.- CTu5D.4, CTu5D.5, CTu5D.6, CTu5D.7, JTu4A.21
 Archibald, Aaron - PW3H.1
 Arguello, Henry - 3M3G.6, CTu2E.4, CTu5D.1, CTu5D.2, CTu5D.3, JW5E.5, JW5E.7, MW2D.2, MW2D.3
 Arias, Kevin A.- CTu2E.4

Arif, Muhammad - SW2H.3
 Armougom, Julie - LTu5C.6
 Arndt, Christoph - LTu2C.3, LTu3C
 Arnison, Matthew - JW3E
 Artusio-Glimpse, Alexandra B.- Ath2A.2
 Askari, Mehdi - JM4A.10
 Asundi, Anand - MM3D.5
 Ataman, Çağlar - OW2J.6
 Atia, George K.- CM2E.5, MTu2D.3
 Atlan, Michael - DM5F.4
 Attota, Ravikiran - AM3A.4, AW3A.1
 Aubert, Gilles - MW2D.1
 Aubry, Alexandre - JTu5B.7
 Aubut, Nicholas F.- AM3A.3
 Audigier, David - OTh2F.4
 Avramov-Zamurovic, Svetlana - PTu3G.4, PTu5I
 Axford, Daniel - OW2J.2
 Azavedo, Caio - JM4A.12

B

Bacca, Jorge L.- CTu5D.2, JW5E.7, MW2D.2, MW2D.3
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 Baranski, Maciej - JW5E.6
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 Barrera Martinez, Eva O. - JW4A.37
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 Beason, Melissa K.- PW3H.5
 Bechensteen, Arne - MW2D.1
 Becker, Lukas G.- LTu2C.6
 Beckus, Andre - CM2E.5, MTu2D.3

Bedoya, Sebastian - ITu2B.3
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 Bennett, Gisele - JW5I.2
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 Berry, Bruce - PW3H.5
 Berthold, John W.- ATu3A.3
 Bertolotti, Jacopo - JTu4A.41
 Bepalov, Victor G.- DTu2F.7
 Besson, Claudine - SM2H, SM3H.1
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 Betrancourt, Christopher - LTu5C.1
 Betzold, Amber - 3W2G.5
 Bewersdorf, Joerg - JTu5B.4
 Bhardwaj, Jayant - JTu4A.38
 Bi, Hongsheng - CTu2E.7
 Bianco, Vittorio - DTh4B.4, DW5F.1, JM4A.1, JM4A.21
 Bieda, Marcin - DTh3D.4
 Bingemann, Dieter - AM3A.1
 Binkele, Tobias - JW4A.23
 Biondo, Luigi - LM5C.1, LTu5C.2
 Birnbaum, Tobias - DW2F.5, JTu4A.10
 Bisht, Nandan S.- JTu4A.25
 Bittner, Evan - ITu2B.6
 Bizet, Laurent - LM5C.5
 Blanc-Féraud, Laure - MTu2D, MW2D.1
 Blankschtein, Daniel - 3W3G.2
 Blaszczyk, Christopher - PW2I.5
 Blinder, David - DW2F.5, JTu4A.10
 Blokland, Willem - IM2B.6
 Blume, Niels Göran - LM5C.1, LTu5C.2
 Boccara, Claude A.- IM3B.1, JTu5B.7, OTh4C.1
 Bocolini, Alessandro - CM2E.6
 Bohlin, Alexis - LW5C.1
 Böhm, Michael - OTh3E.1
 Bolek, Jan - JM4A.5
 Bonora, Stefano - AM5A.1, JTu5B.1
 Bood, Joakim - LTu2C.2
 Bookey, Henry - AM2A. 3
 Booth, Martin J.- JTu5B.4, OW2J.7
 Borges, Ben-Hur V.- DTh2E.5, JM4A.31
 Börner, Michael - LM3C.5
 Bos, Philip - 3Tu2G.5, IM2B.2
 Bose-Pillai, Santasri R.- PW3H.3
 Bosworth, Bryan T.- AM2A. 4
 Bottcher, Erik - AM3A.5

Boufounos, Petros - MW5D.3
 Bouman, Charles A.- MW5D.1, SM5H.1
 Bouman, Katie - JW3E.3
 Bouquet, Gregory - 3M3G.3
 Boyd, Robert W.- STu3F, STu3F.2, STu5H, STu5H.1
 Braeuer, Andreas S.- LW3C.3
 Branch Bedoya, John W.- IW2B.3, JM4A.37
 Bratton, Kenneth R.- JTu4A.28
 Bright, Collin J.- JTu4A.20
 Bright, Victor M.- IM3B.5
 Briñez de León, Juan C.- IW2B.3, JM4A.37
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 Brolo, Alexandre - DM2F.5
 Bronstein, Alex - CW3B.3
 Brückner, Lukas - LM3C.1
 Brunel, Marc - DM5F.1
 Bryant, Douglas - 3Tu2G.5
 Brydegaard, Mikkel - AW3A.2
 Buckley, Charlotte - JTu5B.3
 Buettner, Lars - OW2J.5
 Bui, Vy - DW2F.4
 Bulbul, Angika - DM3F.3
 Bullen, Peter S.- JW4A.20
 Bunning, Timothy - DM3F.1, IM2B.1
 Burchett, Lee - PW3H.1
 Bürkle, Sebastian - LTu2C.6
 Burns, Patrick M.- SW3H.2
 Burns, Ross - LW2C.4

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 Cadiou, Erwan - LTu5C.5
 Cai, Zewei - DTh4B.5
 Califa, Ran - CTh3C.3
 Camacho, Ariolfo - CTu5D.2, CTu5D.3, MW2D.2, MW2D.3
 Campbell, Loudon - JTu4A.28
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 Canat, Guillaume - SW3H.1
 Cao, Hongkun - DTu2F.4
 Cao, Liangcai - 3M2G.5, DTh2C.5, DTh3D, DTu2F.2, DTu5F.4
 Cao, Xun - JTh3B.2
 Capecchi, Mario - CW2E.3
 Capraro, Ivan - AM5A
 Capsal je, Jean-Fabien - OTh2F.4
 Caramazza, Piergiorgio - CW3B.4

Carminati, Remi - JTu4A.41
 Carras, Mathieu - LM5C.5
 Castañeda, Raúl - DTh2C.4
 Castillo Mixcoatl, Juan - JW4A.37
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 Cegarra Polo, Manuel - OTh3E.3
 Cessou, Armelle - LTu2C.1
 Cezard, Nicolas - LTu5C.6, SM3H.1
 Chakmakjian, Stephen - 3W2G.5
 Champagnat, Frédéric - 3W5G.4
 Chan, Antony - CW2E
 Chan, Hon - ATu3A.1
 Chandler, Talon - MW3D.2
 Chandra, Nitish - MW5D.6
 Chang, Eun-Young - JTu4A.11
 Chang, Hsuan-Ting - JM4A.20
 Chang, Ki Soo - JM4A.16
 Chen, Bing Kuan - JTh3A.2
 Chen, Changchen - SW2H.2
 Chen, Chao Ping - 3W2G.7
 Chen, Hsi-Hsun - DM2F.2
 Chen, Huaijin - AM2A. 5
 Chen, Jun - JTu4A.27, JTu4A.29, JW4A.30
 Chen, Laurence L.- 3W3G.5, 3W3G.6
 Chen, Liang-Yu - AW3A.5, JW4A.32
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 Chen, Moran - SW3H.2
 Chen, Ni - DW2F.2, JTh3A.5
 Chen, Richard - CW2E.1
 Chen, Shin-Juh - AM3A.3
 Chen, Tao - STu2H.4, STu2H.5
 Chen, Timothy - LW3C.4
 Chen, Weidong - JM4A.3, JTu4A.7, JW4A.2, LM5C.4
 Chen, Yanqin - JTu4A.40
 Chen, Yi - LM3C.4, LTu3C.5
 Chen, Yifeng - LTu5C.4
 Chen, Zhouye - CM2E.6
 Cheng, Chau-Jern - DW5F.3, JTu4A.3
 Cheng, Xuemin - CTu2E.7
 Cheng, Yih-Shyang - JW4A.21
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 Chia, Yu-Hsin - DW3F.5
 Chiba, Hiroyuki - ITu3B.2
 Chiquet, Frédéric - SW3H.1
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 Choi, Hee-Jin - DTh3D.3
 Choi, KiHong - DM3F.6

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 Choi, Sungwon - DM3F.6
 Chou, Chia-Cheng - AW3A.5
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 Clive, Peter - AM2A. 3
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 Coetzee, Riaan - LTu5C.6
 Coffaro, Joseph - PW3H.5
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 Colburn, Shane A.- CTh3C.5
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 Cooke, Jacqueline - CW2E.3
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 Cossairt, Oliver S.- 3W2G.2, AM2A. 5, CM2E.1, CM2E.4
 Crabbs, Robert - PW3H.5
 Cramer, Avilash - JM3E.5
 Cree, Michael - 3W2G.4
 Crouch, Stephen - PW2I.5
 Cruz, Maria L.- JM4A.23
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 Danehy, Paul M.- LW2C.4
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 Desse, Jean-Michel - 3W5G.4
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 Di Lena, Francesco - CTh2D.1
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 Diebold, Aaron V.- IM2B.5, MTu2D.6
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 Diemel, Oliver - LM5C.1
 Ding, Pengji - LTu2C.2
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 Dixel, Benjamin - LTu5C.2
 do Carmo, João Paulo P.- DTh2E.5
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 Dorronsoro, Carlos - AW2A.1, OTh4C.2
 Drag, Cyril - LM5C.3
 Dragotti, Pier L.- MW3D.1
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 Elbau, Peter - MM2D.1
 Elmalem, Shay - CW3B.3
 Emerson, Benjamin - LW5C.5
 Emmert, Johannes - LM5C.1
 Engel, Lisa - LM5C.1, LTu5C.2
 Engin, Doruk - SW3H.3
 Escande, Paul - MTu2D.4
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 Estevadeordal, Jordi - LM2C.2, LW5C.4
 Ewart, Paul - LTu3C.4
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 Faccio, Daniele - CM2E.6, CTu2E.2, CW3B.4, IM2B.3
 Falaggis, Konstantinos - DM3F
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 Feng, Shaotong - JTh3B.3
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 Fiolka, Reto P.- JTu5B.5

Fiorino, Steven - PW3H.1, PW3H.3
 Fitzpatrick, Fran - SW3H.2
 Fleischer, Jason W.- CTh2D.5, CTh4A.5, CTh4A.7
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 Foster, Mark - AM2A. 4
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 Frish, Mickey B.- AM3A.3
 Fromager, Michael - DM5F.1
 Fu, Chen - CTu5D.4, JTu4A.21, LM2C.4
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 Gamba, Enrique - AW2A.1, OTh4C.2
 Ganapati, Vidya - CW5B.1
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 Gao, Bruce Z - DTh4B.5
 Gao, Shan - JM4A.29
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 Gavel, Donald T.- OTh2F.1
 Gebert, Florian - LW2C.2
 Gedig, Mike - OTh2F.4
 Gelvez, Tatiana - CTu2E.4
 Gemp, Kevin - IM3B
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Georges, Marc P.- DM5F.3, DTu2F, JTu4A.33
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 Gibson, Emily A.- IM3B.5
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 Glebov, Leonid - ATu2A.2, DTh2E.6
 Glück, Martin - OTh3E.1
 Godard, Antoine - LM5C.3, LTu5C.5, LTu5C.6
 Goetschy, Arthur - JTu4A.41
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 Goldberg, Kenneth - CW2E.2
 Goldenstein, Christopher S.- LTu3C.1
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 Goodman, Joseph W.- JTu3D.1, PW2I.1
 Gopinath, Juliet T.- IM3B.5
 Gord, James R.- LM2C.2, LM2C.3, LM3C.2, LTu3C.3, LW5C.4
 Gorju, Guillaume - LTu5C.5
 Gotchev, Atanas - 3Tu3E.1
 Goyal, Vivek K.- JW4A.38
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 Grandal, tania - ATu3A.2
 Greenspan, Hayit - JW4A.3
 Gréhan, Gérard - DM5F.1
 Grieve, Kate C.- IM3B.1, OTh4C.4
 Groenert, Michael - IM2B
 Gross, Michel - DW5F.5, JW4A.27
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 Gruev, Viktor - 3M2G.3
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 Guacaneme, David - DTh2E.6
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 Guenter, Brian - ITh2B.2
 Guerboukha, Hichem - JW5E.2, MM2D.6
 Guerrero, Andres - CTu5D.1, CTu5D.2
 Guichard, Florestan - LTu2C.1
 Guildenbecher, Daniel R.- LM2C.6, LM3C.4, LTu3C.5
 Guizar-Sicairos, Manuel - JM3E.3
 Gunjala, Gautam K.- CW2E.2
 Guo, Fu-Shiuan - JW4A.21
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 Guo, Kaikai - CW5B.2
 Guo, Min - MW3D.2
 Guo, Pengzhen - SM2H.2
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Gupta, Rajiv - JM3E.5
Guyton, David L.- IM3B.4

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Halls, Benjamin R.- LM3C.2, LTu3C.3
Hammel, Stephen - PW2I.3
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Hangauer, Andreas - LTu5C.4
Hansen, Poul-Erik - JM4A.24
Hao, Qun - CTu2E.7
Hao, Xiang - JTu5B.4
Harb, Charles - JM4A.8
Harfouche, Mark - CW2E.1
Harr, Richard W.- JTu4A.20
Harukaze, Keisuke - 3W5G.3
Harvey, Andrew R.- CM3E.4, JM3E, JTh3A.3
Hasegawa, Shuichi - LW3C.7
Hashemi Rafsanjani, Seyed Mohammad - STu5H.1
Haslett, Thomas - AW2A
Haspel, Carynelisa - PTu3G.3
Haugholt, Karl Henrik - 3M3G.3
Häusler, Gerd - 3M3G.2
Hay, Darrick - STu5H.2
Hayasaki, Yoshio - DTh2E, DTu5F.1
He, Jijun - CW2E.5
He, Kuan - AM2A. 5
He, Wenqi - JTh3B.6
He, Ying - JM4A.17
He, Zehao - 3M2G.5
Heacock, Benjamin - SW2H.3
Heaps, Ronald - JTu4A.28
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Heise, Bettina - MM2D, MM3D.4
Henderson, Robert - CM2E.6
Henn, Mark-Alexander - MM5D.3
Hennelly, Bryan M.- JW4A.7
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Heyes, Jane E.- SW2H.2
Hieda, Keisuke - DTh3D.2
Hilbert, Vinzenz - DTh2E.4

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Hincks, Ian - SW2H.3
Hinojosa, Carlos A.- JW5E.5, JW5E.7
Hiura, Shinsaku - 3W3G.4
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Hochgreb, Simone - LW3C.2
Hoelzer, Philipp - JM3E.2
Holler, Mirko - JM3E.3
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Holtom, Theodore - AM2A. 3
Hölzer, Jonas - LW2C.5
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Honney, Claire - AW3A.3
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Horisaki, Ryoichi - 3M3G.1, CW3B.2
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Hsu, Paul S.- LM2C.2, LM3C, LTu3C.3, LW5C.4
Hu, Chenyu - CTh3C.2, CTh4A.6, JW3E.4
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Huber, Michael G.- SW2H.3
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Irsch, Kristina - IM3B.1, IM3B.4, ITu2B, JTu5B.7
Isbach, Michael - DTh2C.3
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Ishimaru, Ichiro - JM4A.2, JM4A.9, JTu4A.18
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Ivanov, Ognyan - LM3C.6

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Jacquot-Kielar, Justin - DM5F.1
Jagannathan, Govind - DW3F.1
Jain, Ayush - LW5C.3
Jamali, Afsoon - 3Tu2G.5, IM2B.2
Jang, Changwon - 3Tu2G.2
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Javid, Usman - OW3J.3
Javidi, Bahram - 3M5G, 3W3G, 3W3G.1
Javidi, Barham - CW2E.4
Jefferey, Joseph - JM4A.12
Jenks, Kyle R.- CW2E.3
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Jeon, Seok-Hee - JTu4A.2
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Jeon, Wonseok - JTu4A.24
Jeong, Chan Bae - JM4A.16
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Jia, Kemiao - STu2H.3
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Joshi, Neel - ITh2B.2
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Judd, Peter - PTu5I.3
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K, Krishna Moorthy - PW2I.4, SM2H.3
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Ka, Jae-Won - JW4A.17
Kadambi, Achuta - JM3E.5
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Kadlec, Emil - PW2I.5
Kakarenko, Karol - DTh3D.4
Kalski, Christian - LTu5C.2
Kamaci, Ulas - CTu5D.8
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Kanaev, Andrey - PTu5I.3
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Khan, Mohammad A.- JM4A.12
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 Zhou, Haijun - STu2H.4, STu2H.5
 Zhou, Hongqiang - DM3F.2
 Zhou, Hui - MM5D.3

Zhou, Jianhong - CTh3C.4
 Zhou, Meiling - DW3F.7
 Zhou, Wen - JTu4A.9
 Zhou, Wen-Jing - DTh4B.6, DW3F.4
 Zhou, Yi - JW4A.30
 Zhou, Yiyu - STu5H.1
 Zhou, Yongzhuang - CM3E.4
 Zhu, Gang - JW4A.26
 Zhu, Haidong - OW3J.4
 Zhu, Jianqiang - CTh2D.4
 Zhu, Kaiyi - ITu3B.3
 Zhu, Liren - CTu2E.1
 Zhu, Ping - OW3J.4
 Zhu, Wenqi - Ath2A.4
 Zhu, Yunhui - JM3E.1
 Zhu, Zheyuan - CW3B.6
 Zhu, Ziyi - STu5H.2
 Zhuang, Quntao - SW2H.2
 Zhuang, Zhaoyong - JTu4A.22
 Zickus, Vytautas - CM3E.4
 Zilk, Matthias - DTh2E.4
 Zohrabi, Mo - IM3B.5
 Zornoza, Ander - ATu3A.2
 Zou, Wenbin - JTu4A.22
 Zuleta, Ignacio - JW3E.2
 Zumeri, Butrint - LTu5C.2
 Zurauskas, Mantas - OW2J.7

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