FACE2PHASE

3rd edition

PROGRAMME

Face2Phase3

Holography
3D Imaging
Tomography
Phase Retrieval

7-9 NOVEMBER 2022
X Delft
DELFT, THE NETHERLANDS

TU Delft

Face2Phase^3 Programme

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WELCOMING MESSAGE

Dear Participant of Face2Phase3,

We are happy to greet you as participant of Face2Phase 3rd Edition. This conference is organised by the TU Delft and is sponsored by ASML, Zeiss, Single Quantum, NWO and DOC. During the Face2Phase conference, particular attention is given to what arguably is the most important property of an optical field, namely its phase. The range of applications considered here is very broad: from inverse scattering using soft x-rays to biomedical detection using a dual comb on a chip.

Tuesday evening at 18:30 h, the conference dinner is held at restaurant Vakwerkhuis, Professor Snijdersstraat 2, 2628RA Delft.

After the conference, on Wednesday afternoon, Thursday and Friday, a SPIE Student Chapter event will take place at the TU Delft.

We wish you a very pleasant stay in Delft!

Face2Phase3

Holography
3D Imaging
Tomography
Phase Retrieval

Prof. Paul Urbach, Chairman of the Face2phase conference and Head of the Optics Research Group at TU Delft.

Optics Research Group
TU Delft

INFORMATION FOR AUTHORS AND ATTENDEES

ORAL PRESENTATIONS

- Time Slots: Invited talks 25 min + 5 min for questions

  Contributed talks 17 min + 3 min for questions
- Technical equipment: You can use your own laptop computer (HDMI or VGA). Alternatively, you can bring your presentation in a memory stick (pdf format with fonts embedded). If you use the stick, put your presentation file on the computer in the hall before the session starts.
- Equipment: Windows-based presentation computer, data projector, Mac adapter, laser-pointer, headset microphone and handheld microphone.

POSTER PRESENTATIONS

- Poster size: A0 Portrait orientation
- Time and Location: The poster session will take place on Tuesday, November 8 between 12.20 h to 13.40 h.
- Set-up: Poster numbers will be displayed on the poster boards. Equipment for poster mounting will be provided. Please put your poster according to the numbering, listed in the program book.
- Poster removal: On Tuesday (16.30 h) at the end of the day.
- Authors are requested to be present at their poster during the official poster session.

WLAN- WIFI

- **Name:** Eduroam

INFORMATION FOR ATTENDEES

REGISTRATION DESK

The on-site registration desk will be open from Monday 8:30 to Wednesday 11:00.

CONFERENCE DINNER

On Tuesday evening, we have the conference dinner at the Vakwerkhuis. This is only open to the attendees who registered and paid for the dinner.

CATERING

Conference participants may attend the free coffee breaks and lunches during the conference. In the city center, many bars and restaurants are available for dining.

Organising Committee

DR. SILVANIA PEREIRA
Delft University of Technology (NL)

DR. AURÈLE ADAM
Delft University of Technology (NL)

PROF. PAUL URBACH
Conference Chair
Delft University of Technology (NL)

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Lidija Nikolic
Assistant Manager

DR. OMAR EL GAWHARY
Delft University of Technology (NL)

Daily Overview

Monday 7 November 2022

08.30 - 09.15 Registration & Coffee

09.15 - 09.30 Welcome by Prof. Paul Urbach, head of the Optics Research Group, TUDelft.

09.30 - 10.40 Session I

1. ***EUV Lithography: Past, Present and Future*** (*Invited*), *Jos Benschop*, ASML, Veldhoven, The Netherlands.
2. **Beam Curvature as a Strategy for Higher Spectral Bandwidth Throughput in Ptychography**, *Daniel Santiago Penagos Molina*, IAP - FSU Jena, Germany.
3. **Ptychographic Characterization of Extreme Ultraviolet Vortex Wavefronts**, *Antonios Pelekanidis*, ARCNL, Amsterdam, The Netherlands.

10.40 - 11.00 Break

11.00 - 12.30 Session II

1. ***Fluorescence Imaging in Complex Media: Wavefront Shaping and Computational Imaging*** (*Invited*), *Sylvain Gigan*, ENS Sorbonne, Paris, France.
2. **Non-Isoplanatic Lens Aberration Corrections in Digital Holographic Microscopy**, *Tamar Cromwijk*, ARCNL, Amsterdam, The Netherlands.
3. **Chromatic effects in high-harmonic generation, and how to measure them with ptychography**, *Stefan Witte,* ARCNL, Amsterdam, The Netherlands.
4. **Nanostructures for In-Situ Surface-Enhanced Kretschmann-Raether Ellipsometry**, *Peter Petrik,* Technical University of Budapest, Hungary.

12.30 – 13.40 Lunch Break

13.40 - 14.50 Session III

1. **Phases of Vector Wave Beating** (*Invited*), *Ari Friberg*, University of Eastern Finland, Joensuu, Finland.
2. **Coupling Optics and Fluid Dynamics: Dynamic Interferometry from Flow,** *Nandini Bhattacharya*, TU Delft, The Netherlands.
3. **Ghost Crystallography**, *Bernhard J. Hoenders*, University of Groningen, The Netherlands.

14.50 - 15.10 Break

15.10 - 16.30 Session IV

1. **Photonic Chips for Diagnostic Applications** (*Invited*), *Imran Avci*, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands.
2. **Fourier Ptychograpic Dark-Field X-ray Microscopy,** *Mads Carlsen*, DTU, Lyngby

Denmark.

3. **How to Better Confine Photons with 3D Silicon Nanophotonics? Let's Go to the Synchrotron to X-Ray Image our Nanostructure** (Invited), *Willem L. Vos*, University of Twente, Enschede, the Netherlands.

16.30 End of the day, Free evening

Tuesday 8 November

08.30 - 10.00 Session V

1. **Fast Photo-acoustic Histology imaging for Intraoperative Pathology Assessment** (*Invited*), *Larry X-C Yuan*, Nanophotonics Research Center, Shenzhen University, China.
2. **Phase Reconstruction for a Holography System at 600 GHz with Deep Learning Methods**, *Mingjun Xiang*, University of Frankfurt, Germany.
3. **Measurement of the Position and Orientation of Arbitrary Objects Based on Projection on Spatial Modes of Light**, *Arturo Villegas*, ICFO, Barcelona, Spain.
4. **Generation of Arbitrary Vector Bessel Beams and Perfect Vector Beams on Higher-Order Poincaré Spheres with a Single Metasurface**, *Jiaqi Yang*, University of Eastern Finland, Joensuu, Finland.

10.00 - 10.20 Break

10.20 - 12.00 Session VI

1. **Gram-Matrix Description of Electromagnetic Spatial Coherence** (*Invited*), *Tero Setälä,* University of Eastern Finland, Joensuu, Finland.
2. **Anisoplanatic Aberration Control in Multiphoton Holographic Projections**, *Laura Maddalena*, Delft University of Technology, The Netherlands.
3. **X-Ray Phase Contrast and Darkfield Imaging on Laboratory Equipment**, *Clara Magnin*, STROBE laboratory, INSERM, Grenoble, France.
4. **Ultrafast Modelling of Partial Coherent Fourier Scatterometry** *(Invited)*, *Armand Koolen* ASML, Veldhoven, The Netherlands.

12.00 - 12.20 Lunch Break

12.20 - 13.40 Poster Session

13.40 - 14.50 Session VII

1. **Phase Retrieval in Space and Time using Photons Generated by Electron Accelerators** (*Invited*), *Gabriel Aeppli*, EPFL, Lausanne, Switzerland.
2. **Table-Top Material-Specific Extreme Ultraviolet Ptychography at 13.5 nm**, *Chang Liu,* Helmholtz Institute, Jena, Germany.

3. **High-Resolution Wavefront Sensing of Multi-Spectral High-Harmonic Generation Sources Using Ptychography**, *Mengqi Du*, ARCNL, Amsterdam, The Netherlands.

14.50 - 15.10 Break

15.10 - 16.30 Session VIII

1. **Techniques and Technology for Diffraction Limited X-Ray Imaging in Space** (*Invited*), *Dick Willingale*, University of Leicester, United Kingdom.
2. **Noise-Robust Latent Vector Reconstruction in Ptychography Using Deep Generative Models,** *Jacob Seifert*, Utrecht University, The Netherlands.
3. **Parity-Time (PT) Symmetry** (*Invited*), *Carl M. Bender, Washington University, St. Louis, USA.*

16.30 - 18.30 Free Time

18.30 21.30 Dinner at Vakwerkhuis

Wednesday 9 November 2022

08.30 - 10.00 Session 9

1. **Metasurface for Transverse Displacement Measurement** (*Invited*), *Zheng Xi*, University of Science and Technology of China, China.
2. **EUV Diffractive Imaging for Wafer Metrology Using HHG Source and Automatic Differentiation Based Ptychography Algorithm**, *Sven Weerdenburg*, TU Delft, The Netherlands.
3. **Design and Fabrication of Deterministic Symmetric Scattering Media,** *Sudhir Saini*, University of Twente, Enschede, The Netherlands.
4. **A spectrometer for greenhouse gas detection based on photonic crystal filters and computational inversion**, *Ralf Kohlhaas*, SRON, Leiden, The Netherlands.

10.00 - 10.20 Break

10.20 -12.20 Session 10

1. **New Dimensions for Adaptive Optics in Microscopy** (*Invited*), *Martin Booth,* University of Oxford, United Kingdom.
2. **Computational Imaging at Zeiss,** *Lars Loetgering*, Carl Zeiss AG,Jena,Germany.
3. **Phase Conjugation of Multiply Scattered Fluorescent Light with a Wavefront Sensor**, *Marc Guillon*, Université Paris Cité, Paris, France.
4. **Computational Focusing and Imaging Through Scattering Media with Single-Pixel Detected Two-Photon Fluorescence,** *Zhao Shupeng,* Laboratoire Kastler Brossel, ENS-Université PSL, Paris, France.

5. **Spatial and Spectral Information in Scattering Media** (*Invited*), *Allard Mosk,* University Utrecht, The Netherlands.

12.20 - 12.30 Best Poster Prize

12.30 Closing

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Monday, November 7

09:15 Welcome by Prof. Paul Urbach, Conference Chair, Head of the Optics Research Group at TUDelft.

09:30 - 10:40 Session I

09:30 *EUV Lithography: Past, Present and Future* (*Invited*),

Jos Benschop, ASML, Veldhoven, The Netherlands.

For more than 50 years the electronics industry has enabled a revolution in our daily life due to ever decreased feature sizes on our chips enabling faster, cheaper and more energy efficient computing and data storage. This trend is commonly referred to as Moore's Law.

To this day optical lithography has been the key enabler for Moore's Law. It will be explained how a combination of increased Numerical Aperture and reduced wavelengths made this possible.

The latest step in wavelength has been a transition from 193nm ArF laser to 13.5 Extreme UltraViolet (EUV) plasma source. Results obtained with latest NA=0.33 EUV scanners will be shared. Finally status of next generation 0.55 numerical aperture EUV scanner will be shown.

10:00 2. Beam Curvature as a Strategy for Higher Spectral Bandwidth Throughput in Ptychography,

Daniel Santiago Penagos Molina, IAP - FSU Jena, Germany.

We present a detailed analysis of the influence of the spectral bandwidth in ptychography. By tailoring the divergence of the illumination, very large spectral bandwidths can be treated as monochromatic.

10:20 3. Ptychographic Characterization of Extreme Ultraviolet Vortex Wavefronts,

Antonios Pelekanidis, ARCNL, Amsterdam, The Netherlands.

We generate extreme ultraviolet vortex beams via high harmonic generation from a vortex fundamental beam and characterize the resulting polychromatic beams using ptychography. The ptychographic reconstructions indicate that there is conservation of the orbital angular momentum (OAM) expressed as $l_q = ql_1$, where l_1 is the OAM of the fundamental beam and l_q is the OAM of the q^{th} harmonic. The results pave the way for the broad use of vortex beams with well-defined properties for imaging purposes.

10:40 - 11:00 Break

11:00 - 12:30 Session II

11:00 1. Fluorescence Imaging in Complex Media: Wavefront Shaping and Computational Imaging *(Invited)*,

Sylvain Gigan, ENS Sorbonne, Paris, France.

Light propagation in complex media can be coherently controlled, allowing focusing and imaging at depth. Fluorescence is an incoherent process, that is therefore not simply amenable to wavefront shaping technique. Yet linear fluorescence remains a staple tool in imaging and microscopy.

I will discuss how non-invasive fluorescence imaging can be performed in scattering media, exploiting both wavefront shaping and computational tools such as phase-retrieval and non-negative matrix factorization techniques.

11:30 2. Non-Isoplanatic Lens Aberration Corrections in Digital Holographic Microscopy

Tamar Cromwijk, ARCNL, Amsterdam, The Netherlands.

Measuring overlay between two layers of semiconductor devices is a crucial step during electronic chip fabrication. We present a dark-field digital holographic microscope with non-isoplanatic lens aberration correction to improve the accuracy of overlay metrology aiming for sub-nm precision.

11:50 3. Chromatic effects in high-harmonic generation, and how to measure them with ptychography

Stefan Witte, ARCNL, Amsterdam, The Netherlands.

We demonstrate high-resolution, wavelength-resolved wavefront sensing of high-harmonic beams with ptychography. Through multi-modal ptychography combined with a specifically designed sensor mask, we retrieve the spatial complex field distribution for up to eight harmonics simultaneously, with sub-µm spatial resolution. We observe significant dipole-phase-induced chromatic aberration in the HHG beam, as well as wavelength-dependent transfer of wavefront aberrations from the drive laser to the harmonics, providing a powerful tool for attosecond beamline diagnostics.

12:10 4. Nanostructures for In-Situ Surface-Enhanced Kretschmann-Raether Ellipsometry

Peter Petrik, Technical University of Budapest, Hungary.

Combinatorial and periodic plasmonic surface structures were developed to enhance the sensitivity of in-situ ellipsometry at solid-liquid interfaces utilizing the Kretschmann-Raether (KR) geometry. AgxAl1-x layers with variable compositions and Au layers with changing periods and critical dimensions were investigated to improve the performance of sensors based on the KR arrangement.

12:30- 13:40 Lunch

13:40 - 14:50 Session III

13:40 **Phases of Vector Wave Beating** (*Invited*),

Ari Friberg, University of Eastern Finland, Joensuu, Finland.

Interference of two vector fields of different frequencies, leading to a periodic superposition, allows the association of two kinds of phases, a geometric phase due to polarization changes and a dynamical phase due to field evolution. The geometric phase assumes a compact analytical expression in terms of the wave intensities and polarization states. It can also be obtained from the wave intensities and the interference fringe visibility. We have employed both approaches to demonstrate and confirm our results. The sum of the two phases is constant, implying that the dynamical phase depends on the polarization states of the two waves.

14:10 Coupling Optics and Fluid Dynamics: Dynamic Interferometry from Flow,

Nandini Bhattacharya*,* TU Delft, The Netherlands.

To be added

14:30 Ghost Crystallography,

Bernhard J. Hoenders, University of Groningen, The Netherlands.

In [1] is predicted that, using low coherent X-rays, it is difficult to obtain a high-resolution diffraction pattern from an object with a spatially periodic structure. This severely restricts X-ray crystallography and similar techniques. Ghost diffraction technique takes advantage of low coherence and overcomes the bottleneck. [1] Wolf E. Op. Lett 38(20):4023-5, 2013 doi: 10.1364/OL.38.004023

14:50- 15:10 Break

15:10 - 16:30 Session IV

15:10 Photonic Chips for Diagnostic Applications *(Invited),*

Imran Avci, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands.

Photonic chips are becoming more and more available in diagnostic applications such as biosensing and optical imaging. During this talk, I will walk you through these exciting applications and demonstrate how we make these chips in-house using a simple and fast technique.

15:40 Fourier Ptychograpic Dark-Field X-ray Microscopy

Mads Carlsen, DTU, Lyngby Denmark.

Dark-Field X-ray Microscopy is an x-ray imaging- technique that images a crystal by placing an x-ray objective lens in the Bragg-scattered beam to create a real-space image on a detector. The method can image small strains and rotations of the crystal lattice. We have investigated a new approach to the data- treatment based on Fourier Ptychographic Microscopy.

16:00 How to Better Confine Photons with 3D Silicon Nanophotonics? Let's Go to the Synchrotron to X-Ray Image our Nanostructure *(Invited),*

Willem L. Vos, University of Twente, Enschede, the Netherlands.

Three-dimensional (3D) nanostructures are receiving a fast-growing attention for their advanced functionalities in nanophotonics, photovoltaics, novel 3D integrated circuits, and flash memories. The functionality of such nanostructures is fundamentally determined by their complex internal structure. Since any fabricated nanostructure inevitably differs from design, the observed functionality differs from expectation. It is thus vital to assess the structure of a 3D nanomaterial with methods that keep the device fully functional and ready for further integration. Hence, we introduce traceless X-ray tomography (TXT) as a tool in nanotechnology to non-destructively assess the functionality of nanostructures, in particular in nanophotonics.

Traditionally, a new nanostructures is inspected by scanning electron microscopy (SEM). A major limitation of SEM is that only the external surface is seen and the inside remains hidden. To inspect 3D structures, SEM is supplemented with ion beam milling to cut part of the structure away. Clearly, this approach is destructive and irreversible. Here we achieve nm resolution in structures on thick substrates using X-ray holographic tomography at the ESRF synchrotron with high photon energies. We study 3D photonic band gap crystals made from Si by CMOS-compatible means, as a prime example of 3D silicon nanophotonics. Such nanocrystals are powerful tools in cavity quantum electrodynamics (cQED) to control the quantum emission of light by their complete 3D photonic band gap.

It appears that in nanophotonics, it is crucial where the involved quantum emitters (in our case: semiconductor quantum dots) are located inside the nanostructure, as this critically determines excited state lifetimes. Therefore, we have embarked on a project to control the positions of the quantum dots with advanced brush co-polymer surface chemistry. To find out where the quantum dots are located, we performed an X-ray fluorescence imaging tomography that will be elaborated. Strengths and limitations, and exciting future directions will be discussed.

. 16.30 End of First Day, Evening Free

Tuesday, November 8

08:30 – 10:00 Session V

08:30 Fast Photo-acoustic Histology imaging for Intraoperative Pathology Assessment *(Invited),*

Larry X-C Yuan, Nanophotonics Research Center, Shenzhen University, China.

Histological analysis is the currently gold standard for surgical margin assessment, whereas a time-consuming preparation of histology slices precludes intraoperative histopathological interpretation of tumor margins during cancer surgery. Ultraviolet photoacoustic microscopy offers the same contrast label-freely as hematoxylin labeling in conventional histology examinations, which however fails to resolve the fine anatomic structures along the depth resolution because of poor axial resolution from the limited ultrasonic detection bandwidth. By exploiting ultrafast temporal dynamics and highly-localized evanescent field of optical surface wave, broadband response to photoacoustic impulses is accessed with high sensitivity, thus improving the depth resolution that is comparable with the standard histology slice thickness. Incorporating the novel sensor into ultraviolet photoacoustic microscope, three-dimensional histology imaging of cell nuclei is obtained in freshly-harvested tissues without sectioning and staining, allowing for fast, accurate intraoperative histopathology assessment for tumor resection surgeries.

09:00 Phase Reconstruction for a Holography System at 600 GHz with Deep Learning Methods,

Mingjun Xiang, University of Frankfurt, Germany.

Two novel phase retrieval methods for THz holography based on physics-informed deep learning are presented.

09:20 Measurement of the Position and Orientation of Arbitrary Objects Based on Projection on Spatial Modes of Light,

Arturo Villegas, ICFO, Barcelona, Spain.

We put forward a technique to estimate the position of an optical beam in a 2D plane. The technique can also be used to estimate the orientation of an arbitrary object. We evaluate the sensitivity of this method and compare it with other techniques as well as with the ultimate limit given by the Quantum Cramer Rao bound.

09:40 Generation of Arbitrary Vector Bessel Beams and Perfect Vector Beams on Higher-Order Poincaré Spheres with a Single Metasurface,

Jiaqi Yang, University of Eastern Finland , Joensuu, Finland.

We introduce a novel method to create, by means of a single metasurface, arbitrary vector Bessel beams and perfect vector beams to cover the entire higher-order Poincaré sphere. The beams can carry both orbital and spin angular momentum.

10:00 - 10:20 Break

10:20 - 12:00 Session VI

10:20 Gram-Matrix Description of Electromagnetic Spatial Coherence *(Invited),*

Tero Setälä, University of Eastern Finland, Joensuu, Finland.

We introduce a novel description of spatial coherence properties of random electromagnetic light beams in terms of the Gram matrix related to the cross-spectral density (CSD) matrix. This leads to the singular-value representation and Poincaré sphere visualization of (two-point) spatial coherence.

10:50 Anisoplanatic Aberration Control in Multiphoton Holographic Projections,

Laura Maddalena, Delft University of Technology, The Netherlands.

We propose a sensor-less adaptive optics approach to correct local aberrations in holograms used for two-photon stimulation. Our method showed intensity enhancement of at least two-fold in holograms projected into fixed zebrafish tissue.

11:10 X ray Phase Contrast and Darkfield imaging on laboratory equipment,

Clara Magnin, STROBE laboratory, INSERM, Grenoble, France.

Phase contrast imaging (PCI) and Darkfield (DF) imaging are recent X-ray imaging modalities that give access to different information and contrasts from those provided by the conventional absorption X-ray images. However, the acquisition of these two types of images is nowadays restricted to synchrotrons because they require the use of coherent sources. This work demonstrates the possibility to efficiently perform phase contrast and darkfield imaging on a laboratory low-coherence system with a conventional X-ray tube. The transfer was made possible on Xenocs SAS laboratory equipment by adapting the method called "Modulation based imaging" (MoBI).

11:30 Ultrafast Modelling of Partial Coherent Fourier Scatterometry *(Invited),*

Armand Koolen, ASML, Veldhoven, The Netherlands.

In semiconductor device manufacturing, optical wafer metrology is a key technology for advanced control of the lithographic patterning in the multiple layers of an integrated circuit (IC). One such optical wafer metrology method is Fourier scatterometry, where the far-field diffraction pattern of periodic structures on the wafer is measured. In case of grating-on-grating wafer targets the lateral displacement, or overlay, between two IC layers can be measured using a technique called Diffraction-Based Overlay (DBO).

The complexity of signal formation in Fourier scatterometry under realistic conditions, i.e. in the context of optical sensor imperfections, depends a lot on the spatial coherence regime in which the Fourier scatterometer is operated. Only the fully coherent or fully incoherent limit allow for the use of fast 2D convolution models to predict the far-field patterns under such conditions. In the partial coherent regime, where the relative size between illuminated wafer spot and target is variable, 4D overlap integrals arise that do not allow for on-the-fly far-field predictions. In this talk we will present a perturbative technique, together with advanced analytical mathematics, that allows us to reduce the complexity of modelling partial coherent Fourier scatterometry to an ultrafast 2D convolution. The approach is fully vectorized and capable of predicting the impact of partial coherence and optical sensor properties on all Stokes parameters.

12:00- 12:20 Lunch Break

12:20- 13:40 Poster Session (see Program in page 22)

13:40 - 14:50 Session VII

13:40 Phase Retrieval in Space and Time using Photons Generated by Electron Accelerators *(Invited),*

Gabriel Aeppli, EPFL, Lausanne, Switzerland.

Over the last 50 years, electron accelerators, including both rings and linear machines, have exhibited an exponentially growing ability to deliver coherent photon beams of entirely variable wavelength. We show how this has already led to full three-dimensional lensless imaging of complex systems such as integrated circuits as well as to quantum state preparation in the time domain. New developments both for synchrotrons and free electron lasers promise dramatic future development of such capabalities.

14:10 Table-Top Material-Specific Extreme Ultraviolet Ptychography at 13.5 nm,

Chang Liu, Helmholtz Institute, Jena, Germany.

We present our latest results on table-top ptychographic imaging at 13.5 nm. Quantitative amplitude- and phase images were obtained with sub-20 nm spatial resolution. Investigations of silicon- based semiconductor samples and microorganisms are enabled with excellent material-specificity.

14:30 High-Resolution Wavefront Sensing of Multi-Spectral High-Harmonic Generation Sources Using Ptychography

Mengqi Du, ARCNL, Amsterdam, The Netherlands.

We perform high-resolution multi-spectral wavefront sensing on extreme ultraviolet sources produced by high-harmonic generation processes. Using ptychography, we show spectrally-resolved complex-valued beam reconstructions for eight harmonics simultaneously, with a spatial resolution of 1 μm.

14:50 - 15:10 Break

15:10 - 16:30 Session VIII

15.10 Techniques and Technology for Diffraction Limited X-Ray Imaging in Space *(Invited),*

Dick Willingale, University of Leicester, United Kingdom.

How can we design and manufacture mirrors, lenses and interferometers which can provide ultra-high angular resolution at the diffraction limit in X-ray telescopes? I will review the prospects of achieving diffraction limited X-ray imaging for astronomical observation in space.

15.40 Noise-Robust Latent Vector Reconstruction in Ptychography Using Deep Generative Models,

Jacob Seifert, Utrecht University, The Netherlands.

We are introducing a reconstruction framework for ptychography for low-photon measurements. We demonstrate the pre-training of a deep generative model and subsequently use it to search for the object solution in latent space.

16.00 Parity-Time (PT) Symmetry *(Invited),*

Carl M. Bender, Washington University, St. Louis, USA.

By using complex-variable methods one can extend conventional Hermitian quantum theories into the complex domain. The result is a huge and exciting new class of parity-time-symmetric (PT-symmetric) theories whose remarkable physical properties are currently under intense study by theorists and experimentalists. Many theoretical predictions have been verified in recent beautiful laboratory experiments.

16.30 Free Time till Dinner

18:30 -21:30 Dinner at Vakwerkhuis

08:30 - 10:00 Session IX

08:30 Metasurface for Transverse Displacement Measurement *(Invited),*

Zheng Xi, University of Science and Technology of China, China.

A long-range, high-precision and compact transverse displacement metrology method is of crucial importance in many research areas. In this talk, after briefly reviewing our previous work on nanoantennas for transverse displacement metrology, we will discuss our recent work on the polarization-encoded metasurface for sensitive long-range transverse displacement metrology. The transverse displacement of the metasurface is encoded into the polarization direction of the outgoing light via the Pancharatnam-Berry phase, which can be read out directlyaccording to the Malus law. We experimentally demonstrate nanometer displacement resolution with the sub-nanometer precision for a large measurement range of 200 mm.

09:00 EUV Diffractive Imaging for Wafer Metrology Using HHG Source and Automatic Differentiation Based Ptychography Algorithm,

Sven Weerdenburg, TU Delft, The Netherlands**.**

We present the soft X-ray beamline constructed at TUDelft using an HHG source for EUV diffractive imaging and demonstrate the results reconstructed using automatic differentiation (AD) based ptychography algorithm at 18 nm.

09:20 Design and Fabrication of Deterministic Symmetric Scattering Media,

Sudhir Saini, University of Twente, Enschede, The Netherlands.

We investigate how light propagates through a deterministic mirror-symmetric multiple- scattering media. Our samples are nanofabricated using a direct laser writing technique. The optical characterization results establish polarization- dependent deviations at the symmetry plane of the bulk ensemble-averaged intensity distribution when pumped in an equally mirror-symmetric way. We model our experiments with FE numerical methods, which validate the experimental results in the multiple-scattering regime.

09:40 A spectrometer for greenhouse gas detection based on photonic crystal filters and computational inversion,

Ralf Kohlhaas, SRON, Leiden, The Netherlands.

Next generations of greenhouse gas observing satellite instruments will need an improved spatial and temporal resolution while keeping similar requirements on accuracy and precision as current instruments. In order to prepare for satellite constellations which can fulfill these requirements new concepts are needed for the minituarization of imaging spectrometers. In this presentation we will discuss one possible approach, based on the computational reconstruction of an input spectrum from a a set of photonic crystal filters with mutually uncorrelated transmission spectra.

10:00 - 10:20 Break

10:20 – 12:20 Session X

10:20 New Dimensions for Adaptive Optics in Microscopy *(Invited),*

Martin Booth, University of Oxford, United Kingdom.

Adaptive optics (AO) is being widely adopted to correct phase aberrations introduced by microscope optical systems and specimens. These aberrations compromise image quality by reducing contrast and resolution. Adaptive elements, such as deformable mirrors or liquid crystal spatial light modulators, are used to modulate the optical wavefronts and remove aberrations. Such AO systems have been developed for microscope applications ranging from deep-tissue imaging of neural activity to super-resolution microscopy. However, AO can be applied to optical properties other than phase. We will discuss developments in spatiotemporal control of short-pulse lasers and light polarization can further enhance the AO microscopy toolkit beyond solely phase correction.

10:50 Computational Imaging at Zeiss,

Lars Loetgering, Carl Zeiss AG, Jena,Germany.

Precision manufacturing has been a central driver for innovation at ZEISS for more than a century. In addition, technological progress nowadays increasingly builds upon data-driven and algorithmic solutions – often resulting not only in cost savings but also in increased performance. In this talk, we give a selective overview on computational imaging activities, ranging from phase contrast microscopy to optical hardware co-design via machine learning.

10:50 Phase Conjugation of Multiply Scattered Fluorescent Light with a Wavefront Sensor

Marc Guillon, Université Paris Cité, Paris, France.

Multiple scattering in biological tissues critically distorts light beams into highly complex speckle patterns. Performing optical phase conjugation using a fluorescent guide star turns out to be especially challenging for several reasons: the weakness and the large spectral width of the fluorescent signal and the absence of reference beam preventing digital holographic measurement of the wavefield. Here we thus use a high-resolution wavefront sensor to measure the broadband fluorescent speckle signal coming from a microbead, taking advantage of the achromatic multiple scattering process at play in forward scattering samples.

10:50 Computational Focusing and Imaging Through Scattering Media with Single-Pixel Detected Two-Photon Fluorescence

Zhao Shupeng, Laboratoire Kastler Brossel, ENS-Université PSL, Paris, France.

In this work, we demonstrate a method that can focus on multiple single guidestar through scattering medium with a spatial light modulator (SLM) and a bucket detector using two-photon fluorescence signals. A gradient descent based multiplexed phase retrieval algorithm is used to non- invasively reconstruct the transmission matrix between the guidestars and the SLM, without any assumptions on the memory effect range. Conversely, if we consider the memory effect, we can reconstruct the image of the sample.

10:50 Spatial and Spectral Information in Scattering Media (Invited),

Allard Mosk, University Utrecht, The Netherlands.

The usefulness of adaptive wavefront shaping methods for focusing, imaging and metrology in scattering media has been demonstrated in many experiments and is making its way into applications. In very strongly scattering media, transport of energy and information takes place through a small number of open transport channels. The properties of these channels have come under intense scrutiny. We will show how measurements, simulations and random matrix theories reveal the spectral and spatial properties of the open transmission channels, and their strong dependence on the fraction of available information in the scattering matrix that we are able to access.

12:20-12:30 Best Poster Prize

12:30 Closing

The poster Session will be held on Tuesday 8 November from 12.20 -13.40

P01 Feasibility study of single-shot X-Ray phase contrast imaging at high energy

M. Bouvier[1], *O. Durand*[1], *A. Stolidi*[2], *V. Brandon*[1]
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A numerical evaluation of X-Ray phase contrast imaging in single-shot and high energy configurations (up to 300 keV) is performed. A Fourier optics approach is developed and used to simulate the propagation of a spherical wavefield and its interaction with several experimental elements (sample, gratings and detector). Two experimental configurations are studied: the free-space propagation and the Talbot-Lau interferometry. Both methods are compared and the possibility to use them with high energy X-Ray source is investigated.

P02 Vectorial PSF model with field dependent aberrations using Nodal Aberration Theory

I.E.A.C. Droste, S. Stallinga, B. Rieger
Department of Imaging Physics, Delft University of Technology, Delft, The Netherlands

A vectorial PSF model that takes into account optical aberrations and emitter dipole orientation can lead to higher localization accuracy in Single Molecule Localization Microscopy (SMLM). According to Nodal Aberrations Theory (NAT), optical aberrations depend on the FOV coordinates through low order polynomials. We plan to develop an a method that fits field dependent aberrations directly from single molecule data using the constraints imposed by NAT.

P03 Thin Film Device Characterization using Picosecond Ultrasonics

R.H.Guis,[1] *M. Robin*,[1] *M. Lee*[2], *G. Verbiest*[1]
[1] Department of Precision and Microsystems Engineering, Delft University of Technology, Delft, The Netherlands
[2]Kavli Institute of Nanoscience, Delft University of Technology, Delft, The Netherlands

We have used Picosecond Ultrasonics to look at acoustic resonances of thin films. We confirmed a mode at 233GHz in a $BaTiO_3$ FBAR device. In a pressure sensor device we used the amplitude decay of the mode in $SrTiO_3$ to demonstrate and adhesion improvement in a SiO_2-$SrTiO_3$ interface after annealing the device.

P04 Two phase contrast methods to study CFRP stricken by lightning

Laureen Guitard,[1,2] *Adrien Stolidi*,[1] *Amélie Jarnac*[3] *and Jérôme Primot*[2]
[1] Université Paris Saclay, CEA, List, F-91120, Palaiseau, France
[2] Université Paris-Saclay, ONERA, DOTA, F-91123 Palaiseau, France
[3] Université Paris-Saclay, ONERA, DPHY, F-91123 Palaiseau, France

There is a growing demand for carbon fiber reinforced polymers (CFRP) in the aeronautic industry. Lightnings can damage them and create complex defects in their structures. It could have serious repercussions on their lifespan. The objective is to understand these defects to minimize them. In this way, an approach involving a lightning strike controlled in laboratory coupled with non-destructive evaluation (NDE) has been discussed. If many NDE methods are used to study CFRP [1], X-ray imaging allows volume inspection with high spatial resolution. However, low attenuation carbon materials bring low contrast on the image. Fortunately, the consideration of the phase signal

of the X-ray wave front, modified by the sample, in addition to the attenuation signal, improve characterisation. This work presents an analysis of CFRP panels impacted by lightning current waveforms using X-ray phase contrast (XPC) images. The study is carried out on both synchrotron light source (on ID19 at ESRF) and laboratory bench (at CEA List).

P05 Detecting continuous structural heterogeneity in single-molecule localization microscopy data

S.Haghparast, B.Rieger, S.Stallinga
Department of Imaging Physics,Delft University of Technology, Delft, The Netherlands

The fusion of multiple chemical identical complexes, so-called particles, in localization microscopy, can improve the signal-to-noise ratio and overcome under labeling. To this end, structural homogeneity of the data must be assumed. Biological heterogeneity, however, could be present in the data originating from distinct conformational variations or (continuous) variations in particle shapes. We present a prior-knowledge-free method for detecting continuous structural variations in localization microscopy. Moreover, detecting structural heterogeneity leads to more faithful fusions and reconstructions of the localization microscopy data as their heterogeneity are taken into account.

P06 Using Actinic EUV Reflectometry for the Characterization of Material Properties of High-NA EUV Thin Films, Stacks, and Photoresists

N.N. Kissoon,[1] K.M. Dorney,[2] E. Witting Larsen,[2] F. Holzmeier,[2] I.A. Makhotkin,[3] V.Philipsen,[2] J.S. Petersen,[2] S. De Gendt,[1,2] P. van der Heide,[2] C. Fleischmann[1,2]

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Actinic EUV reflectometry is performed in imec's AttoLab on EUV photoresists, thin films, and stacks to obtain their structural properties and optical constants. Preliminary experimental results yield optical constants in agreement with published data.

P07 Coherent Fourier scatterometry nanoparticle detection enhanced by synthetic optical holography

Haoyang Yin, Dmytro Kolenov, Silvania Pereira
Optics Research Group, Faculty of Applied Sciences, Delft University of Technology, Delft, The Netherlands

By combining coherent Fourier scatterometry (CFS) with Synthetic Optical Holography (SOH) we show that the sensitive of detection of isolated nanoparticles on surfaces can be substantially improved. This improvement is a result of the boost in the signal at the detector due to the added reference beam, and the reduction of background noise caused by the electronics.
We demonstrate an improvement of sensitivity of about 4B detect for the case of detection of a 60 nm polystyrene latex (PSL) particle on a silicon wafer at wavelength of 633 nm (~λ/10).

P08 Sub-surface laser engraving to manufacture test samples for 3D phase imaging methods

D.S.J.Kooijman, J.Seifert, M. Vreugdenhil, A.P. Mosk
Utrecht University, Physics Department, Utrecht, The Netherlands

We are introducing a method to create 3D samples through sub-surface laser engraving. The 3D samples can be used for 3D phase imaging methods such as tomography, ptychography, or holography.

P09 PyPhase – current developments of the phase retrieval Python package

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[4] Division of Synchrotron Radiation Research and NanoLund, Department of Physics, Lund University, SE-221 00, Lund, Sweden

PyPhase is a Python package for phase retrieval from X-ray in-line phase contrast images. We present the developments in progress, most importantly including several non-linear iterative algorithms, but also the extension of data sources, improvement of code reusability, and improvement of the image registration module. Planned extensions include an improved simulation module, implementation of more phase retrieval algorithms, notably deep- learning based methods, and extension to other techniques such as speckle-based X-ray imaging.

P10 Optical Quality Estimation of Objectives for 4pi Microscopes

Q. Li, S. Stallinga, B. Rieger
Department of Imaging Physics, Delft University of Technology, Delft, The Netherlands

4Pi microscopy uses two opposing placed objective lenses to obtain three-dimensional high-resolution images with sharpened axial point spread function (PSF). Enhanced axial resolution is realized by unwrapping the interference phases, yielding an isotropic imaging resolution of sub-10 nm in theory. In practice, however, the resolution is limited due to suboptimal analysis methods and aberrations introduced by optical components. In this work, we propose a protocol for optical quality estimation of 4Pi microscopes.

P11 4.7 THz beam multiplexing using an asymmetric phase grating for GUSTO

B. Mirzaei,[1] *Y. Gan,*[2,3] *J. Silva,*[2,3] *J. R. Gao*[1,2]
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[2] SRON Netherlands Institute for Space Research, Leiden, the Netherlands
[3] Kapteyn Astronomical Institute, University of Groningen, Groningen, the Netherlands

A full demonstration of the Fourier phase grating used as 4.7 THz local oscillator (LO) multiplexer for Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory (GUSTO) will be presented. Design, modelling, tolerance analysis, and experimental characterization of the angular and intensity distributions among 2 × 4 output beams and the power efficiency will be reported. This is the first detailed study of a THz beam multiplexer, which will be actually integrated in the observatory.

P12 Deep Gauss-Newton for X-ray in-line phase imaging

Kannara Mom[1]*, Max Langer*[2]*, Bruno Sixou*[1]
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[2] Université Grenoble Alpes, TIMC, La Tronche, France

We propose the Deep Gauss-Newton algorithm which allows us to take into account the knowledge of the forward model in a deep neural network by unrolling a Gauss-Newton optimization method. No regularization or step size need to be chosen, they are learned optimally through convolutional neural networks. The proposed algorithm does not depend on any initial reconstruction and is able

to retrieve simultaneously the phase and absorption from a single-distance diffraction pattern.

P13 Spectral Speckle-Based X-Ray Phase Contrast Imaging

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Recently, spectral x-ray imaging has been combined with several phase contrast imaging methods to improve the retrieved phase with respect to the monoenergetic case. This study presents the first implementation combining spectral imaging with speckle-based phase contrast imaging.

P14 A multi-aperture nulling interferometry telescope on a smallsat for exosolar system exploration

Rogier Norbruis, Jérôme Loicq
TUDelft, Delft, the Netherlands.

Context. Nulling interferometry has been receiving renewed interest as a method to directly image and spectrally characterize planetary objects orbiting close to stars other than the sun (exoplanets), with- out the need for large diameter space telescopes. Through precise combination of the coherent light beams from two or more telescopes, a destructive interferometric fringe can be centered on the target star, blocking most of the stellar light even as its close exoplanet companions are enhanced. A deep and wide interferometric null is preferred as it leaks as little stellar light as possible (as noise), while the geometry of the bright interferometric fringe defines how much exoplanetary light (as signal) and light from other sources such as dust (as noise) is observed. This design problem can be solved by phase shifting and combining beams from each aperture in such a way that it maximizes the exoplanet signal and minimizes the leaked noise.
Aims. We attempt to optimize a multi-aperture ($Napertures$ >2) nulling interferometry telescope for use on a small satellite and compare its scientific yield (In terms of detected and spectrally characterized exoplanets) to similarly sized dual aperture systems. In doing so, we will shed light on the role that aperture geometry and complex beam combination techniques play in the effectiveness of nulling in- terferometry.
Methods. Aperture configurations and beam combination schemes can be numerically simulated to produce interferometric fringe patterns, also known as transmission maps. These maps define where in the observed field of view light is blocked and where it is transmitted. For a given observed exoplan- etary system, the optimal aperture configuration and beam combination technique together will lead to a transmission map which will yield the highest signal-to-noise ratio (SNR) for a target exoplanet, which, given a high enough spectral resolution, may lead to the observation of the planetary spectrum. Furthermore, certain beam combination techniques may reduce optical path distance and tip-tilt errors which could otherwise induce phase incoherence, severely impacting null depth and image contrast. Preliminary results. A numerical model has been created to simulate the transmission maps for arbi- trary input aperture configurations (of up to 6 apertures) and beam combination schemes. The model uses a transmission map to calculate the SNR for each exoplanet in a database of simulated exoplane- tary systems based on Kepler space telescope observations. When a threshold for planetary detection is set (such as SNR ≥ 5) this results in a list of 'detected' exoplanets. The results of the numerical model have been verified against a peer-reviewed model for a proposed nulling interferometry space mission, by setting the input telescope parameters to be

equal.

Next steps. The next steps to be undertaken to reach the stated research aims will involve the optimization of the numerical model to find the configuration that detects the most exoplanets within a given range (< 20 pc) and extract therefrom the telescope parameters. Further research will center around the optimal configuration to read the exoplanet's spectrum, as well as the effect of beam inac- curacies on the transmission map and the optimal configuration to reduce instrumental noise resulting from these inaccuracies.

P15 Phase retrieval enhanced by quantum correlations

Alberto Paniate[1,2], Giuseppe Ortolano,[1,2] Pauline Boucher,[1] Carmine Napoli[1], Silvania F. Pereira[3], Ivano Ruo Berchera[1], and Marco Genovese[1]
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Quantum correlation, such as entanglement and squeezing have shown to improve phase estimation in interferometric setups on one side, and non-interferometric imaging scheme of amplitude object on the other. Here, we propose a technique which exploits entanglement to enhance quantitative phase retrieval of an object in a non-interferometric setting, i.e only measuring the propagated intensity pattern after interaction with the object.

P16 Coherent Fourier Scatterometry for particle detection on structured surfaces

Anubhav Paul, Dmytro Kolenov, Silvania F. Pereira
Optics Research Group, Faculty of Applied Sciences, Delft University of Technology, Delft, the Netherlands

We demonstrate the detection of particles/contamination present on a structured surface using Coherent Fourier scatterometry (CFS) by applying Fourier filtering to the scanned maps, which eliminates background effects due to the electronic noise as well the structure itself. We show that by using filters in the Fourier space we can significantly improve the detection capabilities of the particles present on the structure.

P17 Coherent Fourier Scatterometry for defect's detection on Sic samples

J.rafighdoost, Dmytro Kolenov, Silvania F. Pereira
Optics Research Group, Faculty of Applied Sciences, Delft University of Technology, Delft, the Netherlands

Coherent Fourier Scatterometry (CFS) which is a scatterometry technique that has been applied for grating and nanoparticle detection. Here, it has been challenged to verify the detectability of the so-called killer defects on SiC samples for power electronic applications.

P18 Iterative zero-order suppression in dual-wavelength digital holography

H. Shangguan, H. P. Urbach, J. Kalkman
Imaging Physics, Faculty of Applied Sciences, Delft University of Technology, Delft, the Netherlands

Dual wavelength digital holography enables the measurement of the height of objects without generating 2π phase ambiguity over a range larger than a wavelength. In order to improve the image resolution, we developed an iterative zero-order suppression method.

P19 Coherent Fourier Scatterometry for defect's detection on Sic samples

J.rafighdoost, Dmytro Kolenov, Silvania F. Pereira
Optics Research Group, Faculty of Applied Sciences, Delft University of Technology, Delft, the Netherlands

Coherent Fourier Scatterometry (CFS) which is a scatterometry technique that has been applied for grating and nanoparticle detection. Here, it has been challenged to verify the detectability of the so-called killer defects on SiC samples for power electronic applications.

P20 Diffraction grating parameter retrieval using non-paraxial structured beams in coherent Fourier scatterometry

S. Soman, S.F. Pereira, and O. El Gawhary
Optics Research Group, Faculty of Applied Sciences, Delft University of Technology, Delft, the Netherlands

Helmholtz Natural Modes (HNMs) form a complete and orthogonal set of solutions to the non-paraxial Helmholtz equation [1]. Each mode is represented by a set of two indices: the radial and azimuthal index. They have a number of properties that makes them interesting to study. For instance, they possess orbital angular momentum but unlike the Laguerre-Gauss modes they are not limited to the paraxial domain and with each mode containing finite energy in contrast to solutions such as Bessel beams. Furthermore, due to their completeness and orthogonality, any arbitrary field can be decomposed in terms of different HNMs. Using these properties, we investigate the use of these modes in coherent Fourier Scatterometry. The scattered field is decomposed numerically into different HNMs by calculating the overlap integral of the scattered field with each mode. We report on the first results of the retrieval of several grating parameters by analysing the weights corresponding to each mode and show the sensitivity of specific modes to specific parameters [2].

[1] O. E. Gawhary, "Helmholtz Natural Modes: the universal and discrete spatial fabric of electromagnetic wavefields," New Journal of Physics, vol. 19, no. 013021, 2017.

[2] S. Soman, S. F. Pereira and O. E. Gawhary, "Diffraction grating parameter retrieval using non-paraxial structured beams in coherent Fourier scatterometry," Journal of Optics, vol. 24, no. 034006, 2022.

P21 Measurement of the Refractive Index of Particle Suspensions Using Spectral Interferometry

P.N.A. Speets, J. Kalkman
Imaging Physics, Faculty of Applied Sciences, Delft University of Technology, Delft, the Netherlands

The concentration and wavelength dependence of the group refractive index and the group velocity dispersion (GVD) between 420 nm and 920 nm of a dense sample of 100 nm silica nanoparticles was measured from the phase of the interference signal. The dependence of the GVD on the volume fraction of particles matches the theoretical model.

P22 Particle fusion of Single Molecule Localization Microscopy data reveals dimer structure of Nup96

W. Wang, [1] A. Jakobi, [2] S. Stallinga, [1] B. Rieger,[1]
[1] Delft University of Technology, Imaging Physics, Delft, the Netherlands
[2] Delft University of Technology, Bionanoscience, Delft, the Netherlands

In this analysis, we present particle averaging of fluorescently labelled Nup96 in the Nuclear Pore Complex followed by data analysis to show that of nucleoporins 96 occurs as a dimer with in total 32 copies per pore. We use Artificial Intelligence assisted modelling in Alphafold to extend the existing cryo-EM model of Nup96 to accurately pinpoint the positions of the fluorescent labels and show the accuracy of the match between fluorescent and cryo-EM data to be better than 3 nm in-plane and 5 nm out-of-plane.

P23 The WKB Approximation Applied to a Scattering Problem

L. Zonneveld, *H.P. Urbach*
Optics Research Group, Faculty of Applied Sciences, Delft University of Technology, Delft, the Netherlands

We investigate the performance of the WKB (Wentzel-Kramers-Brillouin) approximation applied to a problem where a plane wave is scattered by a perfectly electrically conducting cylinder (PEC). The WKB approximation is an asymptotic series that diverges in the scattering problem. Padé summation is used to increase the convergence of the divergent WKB series.

SPIE School of Physics

November 9-11, 2022

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Wednesday 9 November

EEMCS Faculty, Lecture hall Pi

13:55 -14:00 Opening

14:00 -17:00 Lecture 1

How to sum a series if it converges (part 1)

Prof. dr. Carl Bender, Washington University in St. Louis, USA

It almost never happens that one can find the exact analytical solution to a research problem in physics. Usually, the best one can do is to obtain an accurate approximation to the exact solution. The standard approach is to use perturbation theory, but perturbation series almost always diverge, and even if they converge, they often do so painfully slowly. Therefore, it is important to know how to extract information from a slowly convergent or a divergent series. In these lectures we introduce methods for accelerating the convergence of a slowly converging series (Shanks transformation, Richardson extrapolation) and for making sense of and summing a divergent series (Borel and Padé summation).

Thursday 10 November

EEMCS Faculty, Lecture hall Pi

09:30 -12:30 Lecture 2

How to sum a series if it diverges (part 2)

Prof. dr. Carl Bender, Washington University in St. Louis, USA

See above.

12:30-14:00 Break

14:00-17:00 Lecture 3

Geometric Phase and Complementarity

Prof. dr. Ari Friberg, University of Eastern Finland, Joensuu, Finland.

We begin by analyzing the intensity and polarization-state modulations in vectorial Young's dual-pinhole interference and the consequent emergence of the Pancharatnam-Berry geometric phase and the vector wave-particle complementarity. We then examine the intrinsic properties of three-dimensional (3D) light fields whose polarization state does not admit the conventional beam-field representation. Finally, we explore polychromatic surface-plasmon polariton (SPP) fields, establish methods of tailoring their coherence and polarization features, and illustrate planar SPP fields that exhibit orbital and spin angular momentum.

Friday 11 November

3mE Faculty, Lecture Hall F

09:30 -12:30 Lecture 2

Imaging with and without lenses

Stefan Witte, ARCNL, Amsterdam, The Netherlands.

14:00-16:00 Lecture 3

New paradigm for solving inverse problems: Combining physics knowledge with AI by automatic differentiation

Dr. Yifeng Shao, Delft University of Technology, Delft, The Netherlands.

Conventionally, solving inverse problems requires iterative optimization based on a model that simulates the processes of measurement, and building the model requires the knowledge of physics to describe the simulation by mathematics for implementation. Such a procedure often faces two challenges: finding the proper mathematical description and performing the simulation both efficiently and accurately. In the contrast, artificial intelligence (AI), e.g., (deep learning) neural networks, allows building models to approximate the processes of measurement using the knowledge learned from the data.

It is thus of great interest for researchers in various fields to design hybrid models that can benefit from both the physics knowledge accumulated in human history and the flexibility AI offers. In ideal cases, one prefers to describe the measurement processes by physics knowledge, while replacing some key parts of the model with AI. However, integrating AI into conventional models remains a challenge as the optimization relies on computing the gradients of the variables in the models using analytical formulas derived by hand. On one hand, as the model complexity increases, the tedious hand derivation is increasingly impossible. On the other hand, because AI can only be treated as black boxes, in which the derivative of the input with respect to the output is not explicitly known, the chain rule breaks for models involving AI parts.

The remedy to this issue is to build the model, in the conventional sense, on a mainstream AI platform, like TensorFlow or PyTorch, that provides automatic differentiation (AD) functionality. By designing the model as a concatenation of a series of sub-models and guaranteeing that these sub-models, based on either physics knowledge or AI, are differentiable, one can simulate arbitrarily complex measurement processes and always compute the gradients of the variables by AD. This approach thus provides maximum freedom for solving the inverse problems as one only needs to focus on the simulation model and let AD handle the optimization.

In this workshop, we will introduce applying AD to solving a number of inverse problems on the TensorFlow platform. We will illustrate examples from simple cases of solving systems of equations and curve fitting by regression, to more complicated cases of image processing and phase retrieval. We expect the participants to be experienced in programming, preferably in Python, and to have a basic understanding of the math for optimization.

SPIE School of Physics

16:00 Networking & Drinks

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NOTES

PLANNING

Monday 7 November

09:15	09:30	Opening
09:30	**10:40**	**Session I**
09:30	10:00	Jos Benschop
10:00	10:20	Daniel Santiago
10:20	10:40	Antonios Pelekanidis
10:40	11:00	Coffee break
11:00	**12:30**	**Session II**
11:00	11:30	Sylvain Gigan
11:30	11:50	Tamar Cromwijk
11:50	12:10	Stefan Witte
12:10	12:30	Peter Petrik
12:30	13:40	Lunch
13:40	**14:50**	**Session III**
13:40	14:10	Ari Friberg
14:10	14:30	Nandini Bhattacharya
14:30	14:50	Berhard Hoenders
14:50	15:10	Coffee Break
15:10	**16:30**	**Session IV**
15:10	15:40	Imram Avci
15:40	16:00	Mads Carlsen
16:00	16:30	Willem Vos

Tuesday 8 November

08:30	**10:00**	**Session V**
08:30	09:00	Xiao-Cong Yuan
09:00	09:20	Mingjun Xiang
09:20	09:40	Arturo Villegas
09:40	10:00	Jiaqi Yang
10:00	10:20	Coffee break
10:20	**12:00**	**Session VI**
10:20	10:50	Tero Setala
10:50	11:10	Laura Maddalena
11:10	11:30	Clara Magnin
11:30	12:00	Armand Koolen
12:00	12:20	Lunch
12:20	13:40	Poster Session
13:40	**14:50**	**Session VII**
13:40	14:10	Gabriel Aeppli
14:10	14:30	Chang Liu
14:30	14:50	Mengqi Du
14:50	15:10	Coffee Break
15:10	**16:30**	**Session VIII**
15:10	15:40	Dick Willingdale
15:40	16:00	Jacob Seifert
16:00	16:30	Carl Bender
18:30	21:30	Dinner

Wednesday 9 November

08:30	**10:00**	**Session IX**
08:30	09:00	Zheng Xi
09:00	09:20	Sven Weerdenburg
09:20	09:40	Sudhir Saini
09:40	10:00	Ralf Kohlhaas
10:00	10:20	Coffee break
10:20	**12:20**	**Session X**
10:20	10:50	Martin Booth
10:50	11:10	Lars Loetgering
11:10	11:30	Marc Guillon
11:30	11:50	Zhao Shupeng
11:50	12:20	Allard Mosk
12:20	12:30	Best Poster Prize
12:30	12:35	Closing

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