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YOUNG SCIENTIST CONFERENCE

Developments in Optics and Communications x OptoMeeting

DOC x OPTO
RIGA
2026

BOOK OF ABSTRACTS

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Welcome Message

Dear Participant,

On behalf of the Organising Committee, we are pleased to welcome you to the International Young Scientist Conference Development in Optics and Communications (DOC) and OptoMeeting (OPTO) 2026 in Riga, Latvia.

DOC×OPTO brings together young researchers, industry representatives and internationally recognised scientists working in vision science, biophotonics, laser physics, spectroscopy, optical materials and photonic technologies. The meeting provides a platform for scientific exchange, interdisciplinary collaboration and professional development.

We thank all speakers, participants, sponsors and partners for contributing to the success of DOC×OPTO Meeting 2026.

We wish you an inspiring and productive conference.

DOC×OPTO 2026 Organising Committee

Organising Committee

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DAY 1
(01-07-2026)

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July 1ST
Room 105, UL House of Science, Jelgavas iela 3

11:30-12:00	**Registration**	
12:00-12:15	**Opening remarks**	
SWEB Industry insights (Chair: Ēriks Dipāns)		
12:15-13:00	Invited talk	**Dr. David J. Rogers** Nanovation
13:00-13:15	**Coffee break**	
Laser physics & spectroscopy section (Chair: Dr. Mateusz Szatkowski)		
13:15-14:00	Invited talk	**Dr. Valeria Rodriguez-Fajardo** National University of Colombia
14:00-15:15	**Lunch break**	
15:15-15:30	**Sukorno Asad**	Generation of mid-infrared supercontinua by intra-pulse difference frequency generation driven by ultrafast Cr:ZnS laser
15:30-15:45	**Ada Drwęcka**	Photothermal Spectroscopy for High-Sensitivity Measurement of Sub-Bandgap Absorption
15:45-16:15	**Coffee break**	
16:15-18:15	**Workshop, Room 202** (Dr. Valeria Rodriguez-Fajardo) **& lab tour**, UL House of Science	

DAY 2
(02-07-2026)

DOC x OPTO
RIGA 2026

July 2ND
Room 105, UL House of Science, Jelgavas iela 3

9:00-9:45	**Registration**	
Vision science section (Chair: Dr. Tatjana Pladere)		
9:45-10:30	Invited talk	**Dr. Jasleen Kaur Jolly** Jolly Vision Science/ University of Oxford "Using gene therapy to demonstrate the research cycle"
10:30-10:45	**Chiara Maria Mariani**	Impact of Digital Micromirror Device (DMD) bit-depth and refresh rate on Contrast Sensitivity measurement in Visual Psychophysics
10:45-11:00	**Dagni Räppo**	Can the Visual System Adapt to Repeated XR Exposure? A Within-Subject Study of Visual Function, Discomfort, and Eye Tracking
11:00-11:15	**Mariya Misri**	Factors affecting Manual subjective refraction
11:15-11:30	**Coffee break**	
11:30-12:15	Invited talk	**Dr. Benjamin Cromey** BAE Systems Space & Mission Systems, OPTICA, USA "The Roman Space Telescope Wide Field Instrument"
12:15-13:15	**Lunch break**	
Optical materials section (Chair: Jakub Wronski)		
13:15-14:00	Invited talk	**Dr. Shadab Dabagh** Institute of Solid State Physics, University of Latvia
14:00-14:15	**Karlis Bergs**	Compact Quantum Magnetometer Built on a CMOS Imaging Chip
14:15-14:30	**Anete Sapne**	Heterogeneous integrated polymer photonics development in Latvia
14:30-14:45	**Wiktor Krokosz**	Rydberg Atom Calibrated Sensing of a Terahertz Frequency Comb
14:45-15:00	**Coffee break**	
15:00-17:00	**Workshops with invited speakers & social skill workshops (Room 202/203)**	
17:00-18:00	**Poster session (Room 103/104)**	
19:00-21:00	**Social event at the local art center "Zuzeum", Lacplesa iela 101, Riga**	

DAY 3
(03-07-2026)

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July 3RD
Room 105, UL House of Science, Jelgavas iela 3

8:45-9:00	**Registration**	
SWEB Industry panel (Chair: Chiara Maria Mariani)		
9:00-9:30	Invited talk	**Dr. Boris Polyakov** Institute of Solid State Physics, University of Latvia (ISSP UL) "Thermochromic Nanomaterials and Functional Coating for Smart Windows Applications"
9:30-10:00	Invited talk	**Dr. Karolina Orłowska** Gekko Photonics
10:00-11:00	Industry panel	**Dr. Aleksey Zolotarjovs, Rihards Ruska, Dr. David Rogers, Dr. Karolina Orłowska**
11:00-11:30	**Coffee break**	
Biophotonics section (Chair: Wiktor Krokosz)		
11:30-11:45	**Paweł Wyroślak**	Control and Shaping of 2D LED Irradiation in Photodynamic Therapy (PDT)
11:45-12:00	**Weronika Torończak**	Laser-assisted diffraction analysis of red blood cell rheology - deformability trends and oxygen-dependent dynamics
12:00	**Closing remarks, awards & goodbye coffee**	

Contents

Invited Speakers

THE ROMAN SPACE TELESCOPE WIDE FIELD INSTRUMENT

Benjamin Cromey

BAE Systems Space & Mission Systems

The Roman Space Telescope Wide Field Instrument (WFI) will enable revolutionary advancements in astronomical survey science. Instrument sensitivity spans the 0.5–2.3 µm spectral range with a significant increase in field of view, detector sensitivity, and angular resolution compared to existing observatories. The science of the observatory drove tight stability requirements, and necessitated an array of different optical elements within WFI to switch between imaging at different wavelengths, and using two slitless spectroscopic elements. The science also drove the need for an uncommonly high level of detector calibration, requiring an on-board calibration system supported by unique optics, as well as precise stray light mitigation. In 2024, WFI completed its year-long integration and test campaign as a full instrument, including multiple environmental tests, enabling its performance to be studied in operational temperature conditions. This presentation summarizes several key optical performance aspects of the instrument and how they were verified, including bandpass filter wavefront error, stray light control, and optomechanical alignment. The results demonstrate that the WFI is ready to help transform astrophysics as part of the next NASA flagship observatory when it launches this fall.

About the Invited Speaker

Dr. Benjamin Cromey is a Principal Optical Engineer at BAE Systems Space & Mission Systems. He received his PhD in optical sciences from the University of Arizona in 2020. His work includes key roles on NASA missions such as the Roman Space Telescope Wide Field Instrument, and R&D efforts to prepare for the Habitable Worlds Observatory. He actively serves the scientific community in a variety of capacities across SPIE, Optica, and the Astronaut Scholarship Foundation.

MNFE2O4/PVDF MEMBRANE INTEGRATED MICROFLUIDIC CHIP FOR AMOXICILLIN REMOVAL WITH REAL-TIME MONITORING OF PH AND DISSOLVED OXYGEN WITH AN OPTICAL SENSOR

Shadab Dabagh

Institute of Solid State Physics, University of Latvia

The increasing contamination of water resources with antibiotics poses significant environmental and public health concerns due to the emergence and spread of antibiotic-resistant microorganisms. This study focuses on the removal of amoxicillin (AMX), one of the most commonly detected pharmaceutical contaminants, using an advanced microfluidic platform integrated with a polyvinylidene fluoride (PVDF) membrane. To achieve high adsorption efficiency and precise process control, the microfluidic chip incorporates optical pH and dissolved oxygen sensors that enable real-time monitoring of operating conditions during treatment. The adsorption performance of the PVDF membrane was enhanced through the incorporation of $MnFe_2O_4$ nanoparticles with an average particle size of approximately 25 nm. The chemical structure, morphology, crystallinity, and elemental composition of the modified membrane were characterized using FTIR, XRD, FESEM, and EDS analyses, confirming the successful deposition of $MnFe_2O_4$ nanoparticles on the porous PVDF surface. BET analysis revealed that the electrospray modification significantly improved the membrane structure, increasing the specific surface area from 11.09 to 80.87 m^2 g^{-1} and enhancing porosity. Hydrophilicity and thermal stability tests further demonstrated the suitability of the fabricated membrane for filtration applications. Commercial optical sensors from PreSens continuously monitored pH values between 6 and 8 and dissolved oxygen levels between 80% and 120%, ensuring optimal conditions for AMX adsorption. Under a flow rate of 100 µL min^{-1}, the system achieved an amoxicillin removal efficiency of approximately 98.75%. The proposed integrated platform demonstrates the effectiveness of combining microfluidics, functionalized membranes, and real-time sensing for pharmaceutical wastewater treatment while providing a rapid and practical tool for membrane performance evaluation.

About the Invited Speaker

Dr. Shadab Dabagh is a nanomaterials researcher and biosensor specialist with a Ph.D. in Nanomaterials from Universiti Teknologi Malaysia (UTM**)**. With extensive expertise in microfluidic chip design, optical sensing technologies, and advanced nanostructured materials. Currently Dr. Shadab Dabagh focuses on the development of innovative, biosensor-integrated technologies aimed at advancing next-generation diagnostic and analytical platforms at Institute of Solid State Physics, University of Latvia.

USING GENE THERAPY TO DEMONSTRATE THE RESEARCH CYCLE

Jasleen Kaur Jolly

Jolly Vision Science/ University of Oxford

In this talk **Dr. Jolly** will show how research is not a linear process. Basic science leads to clinical trials when developing novel therapies for patients. The lessons learnt can lead back to basic questions that need answering either about patient care or about the visual system. This shows the need for a multidisciplinary approach to research.

About the Invited Speaker

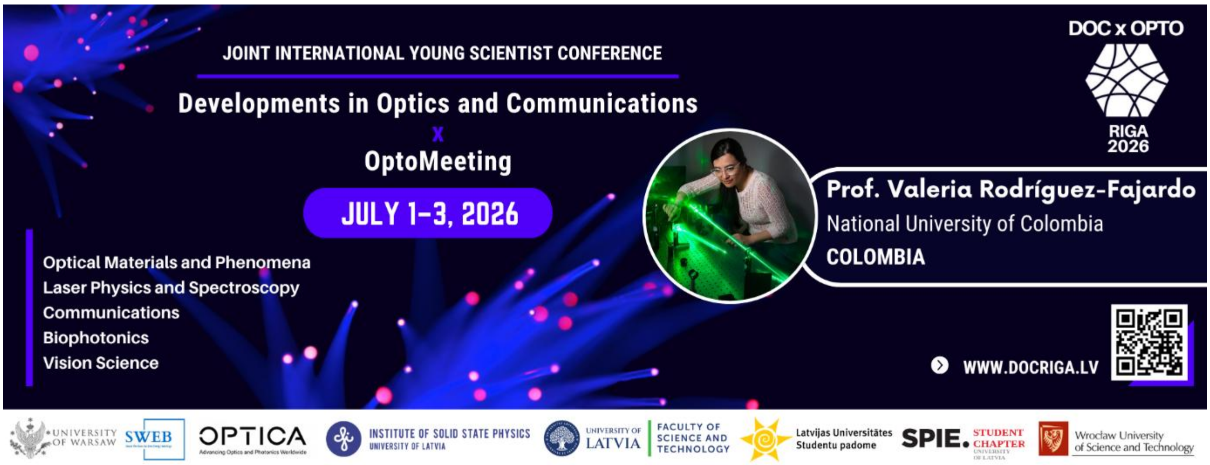
Dr. Jasleen Kaur Jolly is an associate professor in multidisciplinary vision research combining optometry, ophthalmology, neuroscience, and psychology, among other disciplines to primarily focus on three areas. Firstly, outcome measures in novel therapeutics. This can also improve low vision care. Secondly the neuroscience of low vision, including Charles Bonnet Syndrome. Thirdly, the psychology of low vision. Dr Jolly has 94 published papers to date and 2 book chapters. A few years after completing a clinical doctoral fellowship from the University of Oxford in clinical neuroscience she has become an independent academic and consultant working on worldwide clinical trials (Jolly Vision Science), and has an honorary associate professorship in the University of Melbourne.

STRUCTURED LIGHT FOR OPTICAL METROLOGY

Valeria Rodriguez-Fajardo

Universidad Nacional de Colombia

About the Invited Speaker



Dr. **Valeria Rodriguez-Fajardo** is a lecturer at Universidad Nacional de Colombia, investigating the use of structured light in classical and quantum optics. Since her undergraduate studies in Physics, she has been working in the field of optics. Holds a Master's in Optics from the National Institute of Astrophysics, Optics and Electronics (INAOE) in Mexico, and a PhD in Photonics from ICFO - The Institute of Photonics Sciences in Spain. She further specialized in structured light during her postdoctoral fellowships at the University of the Witwatersrand in South Africa and Colgate University in the US. During this time, she has delved into various fields, including holography, plasmonics, optical trapping, optical metrology, and imaging. Valeria's current interests are polarization optics, optical metrology, and quantum imaging.

David J. Rogers

Nanovation

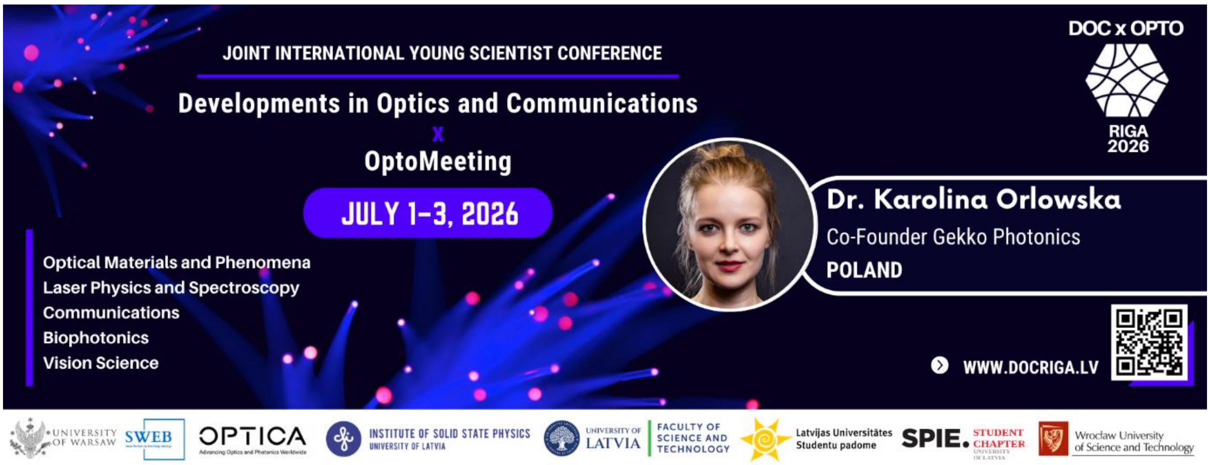
About the Invited Speaker

David Rogers received his PhD in Physics from Glasgow University in 1990. His early career was at Philips Research Laboratories (Netherlands), Carnegie Mellon University (USA) and Nippon Telephone & Telegraph (Japan). In 2001 he co-founded **Nanovation**, which is a fab for innovative oxide semiconductors. Dr. Rogers is the author/co-author of over 30 patents & over 150 publications. He is also an organiser & a regular invited speaker at numerous international conferences. In parallel with developing Nanovation, Dr. Rogers has actively pursued an academic career, and he is currently an adjunct Professor in the School of Mathematical and Physical Sciences at the University of Technology of Sydney.

Karolina Orłowska

Gekko Photonics

About the Invited Speaker



Karolina Orłowska received her PhD from Wrocław University of Science and Technology, specializing in nanometrology. Her research focuses on applied photonics and Raman spectroscopy systems for industrial process analytical technology. She is co-founder and Chief Science Officer of Gekko Photonics, where she leads the development of compact spectroscopic instrumentation for in-line and at-line industrial measurements. Her work spans optical system design, chemometric data analysis, and the translation of laboratory-grade spectroscopic methods into robust field-deployable platforms.

THERMOCHROMIC NANOMATERIALS AND FUNCTIONAL COATING FOR SMART WINDOWS APPLICATIONS

Boris Polyakov

Institute of Solid State Physics, University of Latvia

Tamara Tsebriienko, Institute of Solid State Physics, University of Latvia

Aleksandrs Novikovs, Institute of Solid State Physics, University of Latvia

Thermochromic materials have attracted significant attention as promising candidates for energy-efficient smart window technologies due to their ability to reversibly modulate optical properties in response to temperature changes. Such materials can dynamically regulate solar radiation transmission, thereby reducing energy consumption associated with heating, ventilation, and air conditioning in buildings. Among various thermochromic systems, nanostructured materials and composite coatings offer enhanced optical performance, improved switching behavior, and tunable transition temperatures.

This work presents an overview of thermochromic phenomena, with particular emphasis on thermochromic coatings and nanomaterials designed for smart window applications. The mechanisms of thermally induced optical transitions are discussed, including semiconductor-to-metal phase transitions and temperature-dependent molecular rearrangements. Special attention is devoted to vanadium dioxide (VO_2)-based nanomaterials and hybrid oxide systems, which demonstrate high solar modulation efficiency and visible-light transparency.

The presented overview highlights current challenges and future prospects of thermochromic smart window technologies, including large-scale fabrication, durability, cost reduction, and optimization of optical characteristics for practical applications in sustainable architecture and energy-efficient systems.

Acknowledgment:
This research was supported by the Horizon Europe project SWEB No. 10108736

INDUSTRY PANEL GUEST

Rihards Ruska

Sprayify

The LUMICOAT project, developed by the Institute of Solid State Physics, University of Latvia in collaboration with company Sprayify focuses on the creation of smart bioactive spray coatings for antimicrobial protection. The technology combines biocidal activity with luminescent optical indicators, enabling both effective surface disinfection and visual monitoring of coating performance.

Building on previously developed Dezosil and Fungosil coating systems, the project aims to optimize antimicrobial efficiency and optical properties while ensuring sustainability and cost-effectiveness. Prototype coatings will be tested under real-world conditions to evaluate performance and prepare for future commercialization

LUMICOAT is expected to reduce microbial contamination in public environments such as hospitals and schools, decrease the use of chemical disinfectants, and lower maintenance costs. The integrated luminescent indicator further supports hygiene control by providing a visible signal of coating activity and effectiveness.

INDUSTRY PANEL GUEST

Aleksejs Zolotarjovs

Spectromarine

Spectromarine is a deep-tech water monitoring solution developed at the Institute of Solid State Physics, University of Latvia (ISSP UL). Utilizing an advanced, smart optical sensor system that combines fluorescence and absorption spectroscopy with Internet of Things (IoT) connectivity, the technology delivers real-time, continuous analytics on critical water quality parameters such as dissolved organic matter (DOM), total organic carbon (TOC), and chlorophyll. Spectromarine's primary application lies in Sea Water Reverse Osmosis (SWRO) desalination, where it serves as a predictive tool to detect early biological instability and prevent costly membrane biofouling. Beyond desalination, its robust, minimal-maintenance design is being deployed across aquaculture, post-mining water management, and environmental monitoring systems. To date, Spectromarine has achieved significant international validation and commercial traction. The technology has been field-tested in demanding environments across Spain, the United States, and Saudi Arabia. It won the BRYCK WATER Hub Challenge for smart water analysis and was named a finalist in both the Global Prize Innovation in Desalination (GPID) and the European water sector's prestigious Water Innovation Europe Awards (Digital Water Innovation category). Furthermore, Spectromarine has successfully scaled its pilot deployments globally, tracking real-world parameters for major aquaculture producers, monitoring post-mining sites with Germany's RAG, and providing continuous public safety data on urban lakes.

Oral Session 1: Laser Physics & Spectroscopy

Chair: Dr. M. Szatkowski

GENERATION OF MID-INFRARED SUPERCONTINUA BY INTRA-PULSE DIFFERENCE FREQUENCY GENERATION DRIVEN BY ULTRAFAST CR:ZNS LASER

Sukorno Asad, Maciej Kowalczyk

Wrocław University of Science and Technology

Laser sources in the mid-infrared (MIR) frequency range (3 - 20 μm) are highly sought after – yet notoriously difficult to conceive - for their transformative potential in a wide variety of fields. This includes biomedical analysis, environmental gas sensing, and material processing for manufacturing. Intra-pulse difference frequency generation (IP-DFG) is a convenient MIR generation method which interacts two spectral components of the same driving laser without the need for spatiotemporal overlap. This work studies the performance of different nonlinear crystals, namely Zinc Germanium Phosphide (ZnGeP) and Barium Gallium Germanium Selenide (BaGa GeSe) as two of the strongest candidates in recent literature, to convert an ultra-low-noise mode-locked Cr:ZnS chromium laser with 2.3 μm central wavelength into the MIR via IP-DFG. The interference of cascading DFG signals creates a supercontinuum, and we achieve continuous 1 - 16 μm spectral range with BGGSe at 2 mW average power, and 1-12 μm range with ZGP at 25 mW. We further demonstrate spectral pulse-to-pulse reproducibility through the carrier-envelope-phase (CEP) dependence of the resultant continuum by tuning the CEP of the driving laser. The resultant ultra-low-noise, reproducible, CEP-stable, broadband MIR output offers an ideal medium for spectroscopic applications, particularly for probing the molecular fingerprint of biomarkers in the blood for earlier diagnosis and screening of diseases such as cancers.

Keywords: nonlinear crystals, mid-infrared, frequency conversion, mode-locked lasers, femtosecond lasers

PHOTOTHERMAL SPECTROSCOPY FOR HIGH-SENSITIVITY MEASUREMENT OF SUB-BANDGAP ABSORPTION

Ada Drwęcka, Szymon Zelewski

Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology, 50-370 Wroclaw, Poland

The rapid development of optoelectronic devices based on organic and hybrid materials has increased the need for precise characterization of thin-film active layers. A key parameter governing device performance is energetic disorder, which reflects the sharpness of the absorption edge and is commonly described by the Urbach energy. However, reliably determining this parameter in thin films remains experimentally challenging. Accurate measurement of sub-bandgap absorption requires a dynamic range spanning several orders of magnitude, often beyond the limits of standard transmission-based techniques such as UV–Vis spectroscopy, which are further constrained by light scattering and the low absorbance of films only tens of nanometres thick.

Here, we present an overview of photothermal spectroscopy as a powerful approach for highly sensitive absorption measurements beyond the capabilities of conventional methods. We highlight two established techniques: **photothermal deflection spectroscopy (PDS)**, which probes absorption via pump-induced refractive index gradients detected by a deflected probe beam, and **photoacoustic spectroscopy (PAS)**, which measures pressure waves generated by periodic heating.

We show that photothermal techniques enable not only the detection of weak absorption features and determination of the Urbach energy, but also measurements over a broad spectral range without being limited by the photodetector. For organic and hybrid materials, the dynamic range is extended by up to three orders of magnitude compared with conventional optical absorption methods. These results demonstrate the potential of photothermal spectroscopy for quantifying sub-bandgap absorption in optoelectronic materials.

Acknowledgement: This work was supported by the National Science Centre, Poland, grant no. UMO-2023/51/D/ST5/02836.

Keywords: Photothermal Spectroscopy, Optical Spectroscopy, Absorption, Urbach Energy

Oral Session 2: Vision Science

Chair: Dr. T. Pladere

IMPACT OF DIGITAL MICROMIRROR DEVICE (DMD) BIT-DEPTH AND REFRESH RATE ON CONTRAST SENSITIVITY MEASUREMENT IN VISUAL PSYCHOPHYSICS

Chiara Maria Mariani

University College Dublin

Accurate measurement of the Contrast Sensitivity Function (CSF) is essential for detecting subtle vision loss, yet traditional LED displays often struggle with quantization artifacts and limited temporal precision. This study evaluates how display architecture affects the reliability of quantitative CS measurements using a Digital Micromirror Device (DMD).

We developed a custom psychophysical platform in MATLAB/Psychtoolbox to compare a standard LED monitor against a ViALUX V-7001 DMD system. Five participants performed monocular forced-choice tasks using contrast-modulated Snellen E optotypes. Psychometric functions were estimated via contrast-response curve fitting to analyze threshold stability and slope parameters.

Our results demonstrate that DMD-based stimulation produces significantly steeper psychometric slopes compared to LED presentation, particularly at low-to-mid contrast levels.

This indicates a superior sensitivity to contrast transitions near the threshold. We found that higher temporal refresh rates directly correlate with reduced intra-subject response variance, while increased bit-depth provides the resolution necessary for finer sampling of the psychometric curve. By decoupling bit-depth from refresh rate, the DMD system minimizes quantization errors that often plague conventional displays.

In conclusion, DMD-based projection offers a high-precision alternative for functional vision assessment. These findings highlight the potential for DMD systems to improve the clinical detection of early-stage visual impairments that impact daily performance but remain undetected by standard instrumentation.

Keywords: Digital Micromirror Device, Contrast Sensitivity, Visual perception, Bit-depth resolution

VISUAL ADAPTATION TO REPEATED XR EXPOSURE: A WITHIN-SUBJECT STUDY

Dagni Räppo[1,2], Simone Luca Pizzagalli[2], Martin Argus[1], Tatjana Pladere[3]

[1]Tallinn Health University of Applied Sciences
[2]Tallinn University of Technology
[3]University of Latvia

XR headsets are becoming daily work and learning tools, but their repeated effects on the visual system remain unclear. Most evidence comes from single-exposure studies, while real use occurs across days and weeks. This study examined how visual and oculomotor functions change during repeated VR exposure and whether these changes suggest adaptation.

28 adults completed seven 20-minute Minecraft sessions in a Varjo XR-4 headset across two and a half weeks, with the final session conducted one week after the sixth session as a follow-up. Post-exposure measures included near point of accommodation and convergence, binocular accommodative facility (BAF), visual discomfort, and headset-based eye-tracking metrics.

Repeated VR exposure significantly affected near point of convergence, with a temporary increase during middle sessions before returning toward baseline, while accommodation did not change significantly. BAF improved gradually, and visual discomfort increased after the first exposure but declined across later sessions to near-baseline values. Eye tracking showed significant changes in fixation duration and saccade amplitude, but not in pupil diameter, blink rate, or smooth pursuit velocity.

These results suggest a mixed pattern of stability, short-term strain, and adaptation rather than systematic visual decline. As this work is ongoing, a desktop-based control group will be added to test whether these changes are specific to immersive VR or also occur in physical reality.

Keywords: Extended reality, visual adaptation, oculomotor function, visual discomfort

FACTORS AFFECTING MANUAL SUBJECTIVE REFRACTION

Mariya Misri, Aiga Svede

University of Latvia

Background: Subjective refraction is the gold standard method to determine the best corrected visual acuity by combining the spherical and cylindrical lenses when accommodation is relaxed. This method's accuracy, variability, and repeatability can be reduced by patient, examiner, instrument, and environmental factors that affect the subjective refraction outcome. Moreover, current evidence remains fragmented without an integrated evaluation of these combined influences. **Aim:** To evaluate the factors that influence the accuracy, variability, and repeatability of subjective refraction.

Method: The evaluation was based on peer-reviewed publications identified through a structured literature search in PubMed, Web of Science, and Scopus using Specific keywords. After screening, only free open-access English-language articles related to the topic were included, and articles that were not primary research, not accessible, involved wrong interventions, duplicates, or not in the English language were excluded.

Results: Accommodation, fogging technique, examiner skill, patient understanding, ocular health, and age can affect the variability, accuracy, and repeatability of subjective refraction.

Conclusion: Subjective refraction can be affected by multiple factors. Therefore, improving the standardization of techniques and control of accommodation can enhance its reliability in clinical practice.

Keywords: Subjective refraction, influencing factors, accuracy, variability, repeatability

Oral Session 3: Optical Materials

Chair: J. Wronski

COMPACT QUANTUM MAGNETOMETER BUILT ON A CMOS IMAGING CHIP

Kārlis Bergs

University of Latvia

Nitrogen Vacancy centers in diamonds are great for measuring magnetic fields at room temperature, but the equipment is usually quite large and consumes a large amount of power. Trying to make the sensors smaller results in sensitivity loss. The sensor area shrinks and fewer photons are collected. This research describes building a compact magnetometer directly on top of a standard CMOS camera matrix.

A thin NV diamond membrane is placed directly on the CMOS pixel array and illuminated with an LED. Each pixel acts as an individua; sensor, enabling thousands of simultaneous measurements. Combining signals improves the overall signal to noise ratio and compensates for the reduced sensor size.

Minimizing spin noise from the diamond surface is important because it reduces measurement sensitivity. This is addressed by using high energy helium ion implantation and high vacuum annealing to place the NV centers more than 100 nanometers below the surface.

The rolling shutter of the CMOS sensor is used for readout. A microwave frequency sweep is synchronized with the readout. This encodes the full Optically Detected Magnetic Resonance spectrum into a single frame. Different NV orientations can be distinguished with a static bias magnetic field. This allows a reconstruction of all three components of the magnetic field vector.

This approach demonstrates that standard CMOS imaging technology can be adapted into compact quantum magnetometers, without a significant loss of sensitivity.

Keywords: Quantum Magnetometry, Nitrogen Vacancy centers

HETEROGENEOUS INTEGRATED POLYMER PHOTONICS DEVELOPMENT IN LATVIA

Anete Sapne, Arturs Bundulis

Institute of Solid State Physics, University of Latvia

The advancement of quantum optical technologies depends on the transition to integrated chips based on quantum photonic elements. A significant part of research is focused on integrated quantum sources, for example, Kerr frequency combs which are used for correlated and entangled photon pair generation. There are two main challenges – selecting materials with high nonlinear efficiency and integrating these materials into photonic integrated circuits. Currently multiple photonic platforms are being developed, such as silicon nitride and lithium niobate, but none of these platforms can provide all of the photonic integrated circuit components. Organic materials offer low-power and tunable photonic solutions due to their modifiable molecular structure which allows to influence nonlinear response. Polymers are compatible with other material photonic platforms, and they can be simply integrated through wet-coating methods, which is crucial for heterogeneous platform development. Here we show our progress in development of photon pair sources from glass forming organic materials as well as organic single photon sources. This work covers multiple photonic value chain elements, starting from material research and lithography process to photonic device testing. We have studied nonlinear optical properties of various novel organic materials. Workflows have been developed for passive and active photonic element fabrication using direct laser writing optical lithography. For photon pair generation two types of design were tested - spiral waveguides and frequency combs with ring resonators – and their optical losses were measured.

Keywords: integrated photonics, photonic integrated circuits, nonlinear optics, polymers

RYDBERG ATOM CALIBRATED SENSING OF A TERAHERTZ FREQUENCY COMB

Wiktor Krokosz, Jan Nowosielski, Bartosz Kasza, Sebastian Borówka, Mateusz Mazelanik, Wojciech Wasilewski, Michał Parniak

University of Warsaw

Terahertz (THz) radiation is essential for communications and spectroscopy but lacks practical hardware for coherent signal detection, a limitation known as the **THz gap**. To address this, we developed a room-temperature Rydberg-atom sensor that enables mode-resolved measurements over wide bandwidths.

The sensor utilizes highly excited **rubidium vapor** to couple with THz fields. Key technical components include:

- **Six-wave mixing**: Facilitates parametric RF-to-optical upconversion.

- **Autler-Townes (AT) splitting**: Provides absolute, atom-referenced field calibration.

- **Single-photon detection**: Uses an avalanche photodiode (SPAPD) to achieve sensitivities near the thermal limit.

The THz comb is generated by a **photoconductive antenna** driven by a femtosecond laser with a repetition rate of approximately 80 MHz. By scanning optical detunings, the sensor addresses individual comb teeth with **MHz-scale selectivity**.

The platform achieved the first broadband, single-mode resolved THz comb metrology using an atom-based receiver.

Bandwidth: Accesses regions including 125, 160, 182, and 242 GHz, covering an octave-spanning range.

Sensitivity: The central comb tooth was measured at 405 uV/cm, with an integrated thermal noise of 36 uV/cm.

Scan Range: The spectral scan region where the signal-to-noise ratio exceeds unity reaches over 2 GHz.

Validation: Time-domain signals confirmed inter-mode beat notes predicted by an expanded GKSL theoretical model.

This research establishes a path for THz spectroscopy to achieve the high precision and accuracy previously reserved for optical frequency combs.

Keywords: Rydberg atoms, frequency comb, terahertz spectroscopy

Oral Session 4: Biophotonics

Chair: W. Krokosz

CONTROL AND SHAPING OF 2D LED IRRADIATION IN PHOTODYNAMIC THERAPY (PDT)

Paweł Wyroślak, Maciej Mierkiewicz, Mateusz Badura, Jakub Aniulis, Katarzyna Matczyszyn, Krzysztof Abramski

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The objective of the work is to analyze how control parameters and optical delivery paths influence the irradiance distribution and thermal behavior of a 2D LED illumination system. The project is motivated primarily by methylene-blue-based PDT, while the underlying engineering problem is broader and concerns controlled, repeatable, and measurable optical irradiation. The investigated system includes several beam delivery and shaping strategies, such as an optical-fiber bundle, an aluminum reflective cylinder, and Fresnel lens-based guidance. The experimental plan is also extended to infrared LED matrices at 820 nm, 910 nm, and 1050 nm, using reflective optical guidance.

The methodology combines current-dependent irradiance measurements, two-dimensional mapping of the working field, region-of-interest analysis for representative sample positions, and thermal monitoring of the illumination system. Quantitative evaluation is based on numerical irradiance data, enabling comparison of different optical configurations under controlled operating conditions. Preliminary measurements performed for the optical-fiber and reflective-tube variants confirmed the usefulness of this approach for assessing irradiance level, field uniformity, and thermal stability.

The main outcome of the project is an optoelectronic measurement-control platform supporting reproducible optical dose delivery. The results indicate that optical path selection in PDT experiments should be based not only on achievable irradiance, but also on spatial uniformity, repeatability, and safe thermal operation. This provides a practical basis for selecting and optimizing LED irradiation configurations for future PDT studies.

Keywords: PDT, Irradiance uniformity, illumination systems

LASER-ASSISTED DIFFRACTION ANALYSIS OF RED BLOOD CELL RHEOLOGY-DEFORMABILITY TRENDS AND OXYGEN-DEPENDENT DYNAMICS

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The physiological functionality of red blood cells (RBCs) is intrinsically linked to their mechanical deformability [1]. While techniques like optical tweezers offer high precision, they suffer from low throughput. In this study, we utilize Laser-assisted Optical Rotational Cell Analysis (LORRCA) as a high-throughput robust alternative to monitor the rheological evolution of human RBCs during in vitro storage.

The measurement relies on Fraunhofer diffraction analysis. As RBCs in a Couette flow deform under shear stress, the diffraction pattern shifts from circular to elliptical, enabling real-time quantification of the Elongation Index (EI) [2].

Our 28-day analysis revealed non-trivial rheological trends. A critical transition occurred during the second week of aging, where deformability reached its minimum. This was followed by a slight improvement in mechanical stability in subsequent weeks. Furthermore, our studies demonstrate that older RBC populations exhibit significantly reduced resilience to oxygenation and deoxygenation processes. These findings were substantiated using the innovative Oxygenscan methodology, which measures deformability in a gradient of oxygen partial pressure. The ability to monitor oxygen-dependent mechanical shifts highlights LORRCA's unique capability in identifying metabolic-mechanical correlations inaccessible via static optical methods. This research was funded by a grant from the National Science Center (UMO-2022/47/D/ST7/02938).

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Keywords: red blood cell, diffraction analysis, rheology

Poster Session 1: Vision Science

ASSESSING USER EXPERIENCE IN AUGMENTED REALITY: TASK UNDERSTANDING, IMAGE PERCEPTION, AND VISUAL COMFORT

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University of Latvia, Department of Optometry and Vision Science

Stereoscopic augmented reality (AR) display systems require users to process virtual information overlaid on real-world backgrounds, leading to vergence-accommodation conflicts [1]. While physiological indicators are vital, subjective assessments provide indispensable context for understanding user experience (UX) [2]. Standard tools are often too lengthy for repeated-measures designs, inducing survey fatigue [3]. This study evaluates AR UX and visual comfort using an optimized subjective assessment approach. We utilized a visual comfort questionnaire [4] and an adapted version of the Quality of Experience questionnaire [5], integrating components from several validated instruments. VR-specific "presence" items, redundant statements, and wearable ergonomics-related questions were excluded. The resulting 19-item tool, administered pre- and post-task, was tested in several experiments involving subjects performing tasks using a multifocal AR headset (IG-1050, Lightspace Technologies, Latvia), and feedback was collected. The proposed approach provides a practical framework for evaluating AR usability while reducing user burden. It supports more efficient subjective data collection and offers recommendations for improving UX during prolonged AR use.

Acknowledgment: The research is funded by the Latvian Council of Science, project No. lzp-2024/1-0201.

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Keywords: Augmented Reality, User Experience, Visual Comfort, Subjective Assessment

ASSOCIATION BETWEEN SCREEN USE HABITS AND VISUAL EVOKED POTENTIALS

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Purpose: To investigate the association between daily screen use habits and pattern-reversal visual evoked potentials (VEP).

Methods: A quantitative cross-sectional study included 49 participants (39 females, 10 males). Average daily screen time was estimated using a digital device use questionnaire. Pattern-reversal VEP were recorded with Diagnosys LLC system according to ISCEV standards using black-andwhite checkerboard stimuli reversing at 2 reversals/s with 1.0° and 0.25° check size. Participants viewed the stimuli monocularly from 100 cm while fixating a central target. Linear mixed-effects models were applied to assess associations between screen time and VEP parameters.

Results: No statistically significant associations were found between daily screen time and VEP N75/P100 latencies or amplitudes. Non-significant trends showed slightly reduced amplitudes and prolonged latencies with increasing screen time. Stimulus size significantly affected VEP responses: larger stimuli produced shorter N75 and P100 latencies, lower P100 amplitudes, and higher N75 amplitudes ($p < .01–.001$). Males demonstrated prolonged N75/P100 latencies and lower P100 amplitudes compared with females ($p < .05–.01$). Additionally, 95.9% of participants reported at least one symptom related to prolonged screen use, most commonly dry eyes and headaches. More than half of participants (57.2%) reported taking regular breaks during screen use.

Conclusions: Daily screen time was not associated with significant VEP alterations. Observed VEP differences were primarily related to physiological factors, particularly stimulus size and sex, rather than screen use habits. Although screen-related symptoms were highly prevalent, the electrophysiological findings suggest that pattern-reversal VEP may be more strongly influenced by intrinsic visual system characteristics than by habitual screen exposure.

Keywords: visual electrophysiology, VEP, screen time, digital eye strain

COMPARISON OF VISUAL ACUITY ASSESSMENT METHODS: SSVEP AND FRACT

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Purpose: To evaluate visual acuity (VA) using stepwise sweep visual evoked potentials (ssVEP) and the Freiburg Visual Acuity Test (FrACT), and to compare both methods under fogging lens conditions.

Methods: 30 participants (23 females, 7 males; mean age 21±4 years) were included. VA was assessed using a Diagnosys LLC system with ssVEP checkerboard stimuli of progressively decreasing check size and with the subjective FrACT method using Landolt C optotypes. Fogging lenses of +0.50 D, +1.00 D, +1.50 D, and +2.00 D were applied monocularly to simulate reduced VA. Participants were tested first with ssVEP and subsequently with the FrACT method.

Results: With the FrACT method, VA progressively decreased from M = 1.04 (SD = 0.19) without fogging lenses to M = 0.25 (SD = 0.11) with +2.00 D fogging lenses. ssVEP measurements showed a more gradual decrease, from M = 0.75 (SD = 0.21) to M = 0.52 (SD = 0.17), indicating greater stability but lower sensitivity to defocus. ANOVA revealed no significant overall differences between methods ($F(1,29)=0.47$, $p = 0.50$), while fogging lens strength had a significant effect on VA ($F(2.88,83.38)=131.81$, $p < 0.001$). A significant interaction was found between method and fogging lens strength ($F(3.10,89.85)=58.01$, $p < 0.001$). Spearman correlations between methods were weak and non-significant ($r = 0.064–0.151$, $p > 0.05$). Bland–Altman analysis demonstrated systematic bias, indicating that FrACT and ssVEP are not interchangeable methods.

Conclusions: FrACT was more sensitive to VA changes induced by fogging lenses, whereas ssVEP provided more stable measurements. Although both methods detected reduced VA with increasing fogging lens strength, systematic differences suggest they should not be used interchangeably.

Keywords: visual electrophysiology, ssVEP, FrACT, fogging lens

BLINKING PATTERNS DURING VISION TRAINING

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University of Latvia

Objective: Comparing the blinking rate (blink per min) during the rest (fixation at far; at least 6 m away) and vision training (manual and with the EYE ROLL device). To evaluate the possible discomfort during vision training and its relation to the blinking rate. To analyze the relationship between blinking rate and tear film parameters (tear meniscus height and non-invasive tear break-up time).

Method: A total of 42 healthy volunteers (14 males, 28 females; aged 15-42 years; mean 26 ± 7 years) participated. None had ocular disease or eye surgery. Exercises included horizontal, vertical, diagonal, rotational and far near focusing movements. Three conditions were tested: (1) natural gaze straight ahead (1 min), (2) manual vision relaxation (~4 min), (3) Eyeroll guided vision relaxation (~4 min). No blinking instructions were given. Eye movements were video-recorded; total, full, and partial blinks were analayzed.

Results: Data analyses demonstrated that there was total blink rate decreased significantly across conditions ($F(2,82) = 35.23$; $p < 0.00001$). Largest changes were observed during Eyeroll device exercises. Full blinks decreased significantly ($F(2,82) = 39.25$; $p < 0.001$). while partial blinks were unchanged ($p = 0.07$). No relationship was found between blink rate, tear film parameters or subjective discomfort ($p > 0.05$). The subjective feeling were not affected by the way (manually or with the device) the training was performed (McNemar test: $p = 0.096$).

Conclusions: Total and full blink rates decrease during vision relaxation, especially with Eyeroll exercises, while partial blinks remain stable. Eyeroll use is more comfortable and blinking breaks are recommended to support ocular surface health.

Keywords: blinking, blink frequency, vision relaxation training, EyeRoll

COHERENT MOTION PERCEPTION IN CHILDREN WITH READING DIFFICULTIES

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Reading is an essential skill for child's social and academic development. Beyond the well-established focus on phonology deficits, recent studies highlight the magnocellular system as a one of the factors related to reading performance, facilitating the high-speed visual integration and precise eye movements necessary for fluent text navigation.

This study objectively evaluated magnocellular-driven responses in 105 school-aged children (grades 2, 4, and 6) categorized by the Acadience Reading test into those with reading difficulties (<20th percentile) and those without (>40th percentile). Using a Tobii Pro Fusion eye-tracker, the following parameters of the OKN response were analyzed - accuracy, slow-phase tracking duration, and number OKN cycles within Gabor and coherent motion tasks.

The results revealed that magnocellular performance depends on task type; a statistically significant relationship was found between reading performance and eye movement parameters in the coherent motion task, whereas no such relation appeared in the Gabor task. While a significant age effect was observed across both tasks, the findings overall indicate distinct differences in magnocellular functioning between children with and without reading difficulties. These performance discrepancies are likely related to the specific methods of stimulus generation used for each task.

The current study is supported by the Latvian Council of Science (Postdoctoral project No. 1.1.1.9/LZP/1/24/144).

Keywords: coherent motion perception, reading performance, optokinetic response

EGOCENTRIC RESILIENCE, ALLOCENTRIC DECLINE: A VR-BASED DISSOCIATION OF SPATIAL MEMORY ACROSS THE LIFESPAN

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Where you are and where things are relative to each other are processed by distinct neural systems that do not age equally. Egocentric memory, linked to the parietal cortex, remains relatively preserved in older adults, whereas allocentric memory — the hippocampal ability to form cognitive maps — declines disproportionately. Measuring this dissociation precisely has been difficult because real-world navigation tasks are confounded by semantic memory, attention, and path integration noise.

We developed a minimalist VR protocol (Meta Quest 3) that isolates both spatial reference frames within a single session. Fifty participants — 30 young adults (18–35) and 20 older adults (55+) — completed 32 egocentric and 32 allocentric ball-placement trials in a featureless virtual environment. The allocentric condition introduced scene rotation during recall, forcing true coordinate transformation.

Older adults performed 34% worse on egocentric trials and 91% worse on allocentric trials. The Egocentric-to-Allocentric Ratio (EAR), a novel within-subject index, was significantly lower in older adults (0.57 vs. 0.79, $p = 0.001$), confirming a selective allocentric deficit beyond general slowing. Egocentric error increased with movement distance, while allocentric error scaled with distance from reference landmarks, revealing distinct mechanisms of spatial error.

These findings establish EAR as a sensitive biomarker for hippocampal-linked spatial decline with clinical screening potential.

Keywords: spatial memory, aging, VR

INFORMATION DENSITY SEGMENTATION OF FUNDUS IMAGES VIA OPTIMIZED RÉNYI ENTROPY AND GMM MODELING

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Accurate identification of structurally informative regions in retinal fundus images is essential for reliable blood vessel analysis and early detection of pathology. Conventional entropy-based filters are computationally expensive, limiting their use at multiple spatial scales. In this work, a fast multi-scale filtering approach based on Rényi entropy of order $\alpha=2$ is introduced to highlight areas with high information density.

The objective of the study is to efficiently separate homogeneous retinal background from fine anatomical structures such as blood vessels and small lesions. To achieve this, an optimized sliding-window strategy was employed, in which local entropy values are updated by incrementally adding and removing column contributions. This enables near-constant-time computation across multiple window sizes. The resulting entropy responses were subsequently modeled using a two-component Gaussian Mixture Model (GMM), where one component represents low-entropy background and the other captures high-entropy vascular detail.

Preliminary results indicate clear separation between background and vessel-rich regions. The proposed entropy–GMM pipeline provides an effective and computationally lightweight preprocessing method for vessel segmentation, lesion detection, and may serve as a robust foundation for downstream ophthalmic image analysis.

Keywords: digital filters, information entropy, fundus image analysis

MAXIMIZING DATA UTILIZATION IN HIGH-SPEED RASTER LASER SCANNING MICROSCOPY

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Wrocław University of Science and Technology

Raster scanning using galvanometer mirrors is fundamental to many laser imaging techniques, such as optical coherence tomography, confocal, and multiphoton microscopy. Standard bidirectional scanning suffers from edge distortions caused by the acceleration and deceleration phases of galvanometer mirror motion. To correct, a pixel offset is introduced between successive lines, requiring rejection of affected data points which reduces scan duty cycle efficiency. In biomedical imaging, especially in vivo applications, minimizing acquisition time is critical to reduce the risk of motion artifacts while maintaining high resolution.

We propose an offset-free bidirectional scanning approach that increases the number of usable pixels within the same scan duration. The main challenge is the nonlinear behavior of the scanner, which introduces spatial distortions and irregular sampling. The method accounts for the delay between the control signal and data acquisition relative to the actual mirror position with post-processing correction of scanner nonlinearities. The developed algorithm interpolates the measured scanner motion trajectory to accurately assign signal values to their corresponding spatial positions, correcting distortions due to scanner inertia and nonlinear mirror motion.

Results show improved data utilization without compromising resolution, making this approach promising for high-speed biomedical and vision science imaging applications sensitive to motion artifacts.

Keywords: bidirectional raster scanning, galvanometer scanners, biomedical imaging, high-speed imaging, nonlinear distortion correction

NUMERICAL STUDY ON THE BEHAVIOUR OF THE PHASE SINGULARITIES SPOT DIAGRAM UNDER MANUALLY INTRODUCED OPTICAL ABERRATIONS

Klaudia Saluk[1], Aleksandra Korzeniewska[1], Przemysław Litwin[1], Wiktor Forjasz[2], Jaime Cisternas[3], Maria Cywińska[2], Mateusz Szatkowski[1]

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Accurate measurement of optical aberrations is essential for characterizing and optimizing the performance of optical systems. Here, we propose introducing a new analysis tool that provides another perspective to assess optical aberrations. We study the behavior of singular points under manually introduced aberrations using off-axis optical vortex scanning. By shifting the vortex-generating element and tracking the resulting singular points at the Fourier plane, we construct a dark ray spot diagram, being a singularity analogue of classical ray spot diagrams.

Off-axis scanning was previously proposed as a beam-quality marker to distinguish aberrated from unaberrated beams. To function as a reliable aberrometer, however, quantitative links between trajectories and specific aberrations are required. We previously showed that two perpendicular trajectories - from x- and y-axis shifts - respond uniquely to particular Zernike polynomials, enabling aberration-specific quantities and an autofocusing algorithm.

Here, we extend this approach from two trajectories to a full circular grid. The resulting dark ray spot diagrams offer a novel tool for examining optical aberrations, where each "ray" is a phase singularity - a physically meaningful and sensitive probe of optical system quality. We believe that the presented work offers a new perspective on wavefront sensing and represents a significant research step toward an aberrometer that utilizes phase singularities.

Keywords: wavefront sensing, phase singularity, optical vortex, aberration

OBJECTIVE VERGENCE ANGLE ASSESSMENT IN MULTIFOCAL AUGMENTED REALITY

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Precise vergence eye movements are required for binocular alignment and accurate distance perception. In augmented reality (AR), objective vergence assessment remains challenging due to gaze geometry constraints, calibration issues, and variability between methods. Reliable measurements are needed to better understand binocular adaptation in stereoscopic AR. This study evaluated vergence responses in multifocal AR using two objective methods. Specifically, gaze position was assessed in 14 adults using an eccentric photorefractometer (PowerRef 3, Plusoptix, Germany) and binocular eye-tracking glasses (Neon, Pupil Labs, Germany). Images were displayed using a multifocal AR headset (IG-1050, Lightspace Technologies, Latvia). Measurements were conducted at four image distances (45, 58, 81, and 130 cm) in randomized and sequential order under faster and slower switching modes. By the end of testing, more divergent far vergence was observed. Interestingly, vergence amplitude decreased across trials during the faster image-distance switching mode, whereas this effect was not observed in the slower mode. Overall, both methods showed comparable vergence patterns, supporting the use of both devices for objective vergence assessment in multifocal AR.

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Keywords: multifocal augmented reality, vergence angle, eye tracking, photorefraction

THE DYNAMICS OF FIXATION POSITIONS IN NATURALISTIC LATVIAN READING

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University of Latvia

The present study aims to characterize the Preferred Viewing Location (PVL) and relative fixation positions in native Latvian readers during naturalistic reading tasks. The analysis evaluates four distinct eye movement categories: initial fixation, refixations, the mean position of all first-pass fixations, and the mean position of all second-pass fixations.

The study included 17 native Latvian speakers (aged 18–45; normal or corrected-to-normal vision). Oculomotor data were recorded using an EyeLink 1000+ video-oculograph, following the standardized protocol of MultiplEYE Cost action. Participants read ten texts of varying genres at a natural pace. Relative fixation positions were calculated on a normalized scale (0 = word beginning, 1 = word end) for each fixation category. Statistical analysis was performed using linear mixed-effects models in R (v. 4.3).

The analysis revealed that the mean relative position for all first-pass fixations is located slightly to the left of the word center (M=0.447). The initial fixation exhibited an even more pronounced leftward bias (M=0.421). Conversely, refixation positions were shifted toward the word ending (M=0.547), while second-pass fixations were centered precisely at the word midpoint (M=0.500).

The current findings suggest that fixation position in Latvian language reading is related to the specific phase of information processing. While initial word recognition and subsequent re-reading target the word center for global semantic integration, the marked positioning of refixations at the word ending indicates that the highest cognitive load in Latvian reading is associated with the processing of word suffixes and morphological endings.

The study was conducted with the support of the Latvian Council of Science Fundamental and Applied Research Program, project No. lzp-2025/1-0195, and within the framework of COST Action No. CA21131.

Keywords: Eye movements, reading, fixation position, latvian language

REFLECTION-MODE FOURIER PTYCHOGRAPHIC MICROSCOPY FOR MULTI-CONTRAST, LABEL-FREE IMAGING OF ONION EPIDERMAL CELLS

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Quantitative label-free imaging is important for mapping cellular morphology and intrinsic optical properties without exogenous stains. Fourier ptychographic microscopy (FPM) enables high-resolution amplitude and phase reconstruction, but is often implemented with monochromatic or narrowband illumination, limiting access to wavelength-dependent scattering and absorption contrast. Here, we present a chromatic reflection-mode FPM system, RGB epi-FPM, that uses a programmable red, green, and blue LED array at 630, 530, and 470 nm to sequentially acquire angle-resolved brightfield and darkfield images. A self-calibrated phase retrieval algorithm reconstructs high-resolution amplitude and phase maps independently at each wavelength, providing a synthetic numerical aperture approximately 1.5× larger than the native objective NA.

Experiments on onion epidermal membranes demonstrate wavelength-dependent contrast in both amplitude and phase. Blue illumination enhances fine sub-cellular and cell-wall texture through stronger scattering, whereas red illumination provides smoother phase profiles and improved contrast in thicker cell-wall junctions. By fusing the reconstructed RGB complex fields, the system produces a high-resolution color reflectance image and a composite quantitative phase map that combines the spatial-frequency sensitivity of shorter wavelengths with the phase stability of longer wavelengths. The resulting multi-contrast representation improves visualization of cell-wall boundaries and intracellular heterogeneity compared with monochromatic FPM. Without staining or major hardware modifications beyond a multicolor LED matrix, RGB epi-FPM provides co-registered structural, quantitative phase, and chromatic contrast for label-free plant-cell imaging, phenotyping, and optical characterization of scattering biological tissues.

Keywords: Fourier ptychographic microscopy (FPM), Computational microscopy, Multi-wavelength imaging, Quantitative phase imaging

SPATIAL PATTERNS OF EYE CARE SERVICES IN LATVIA

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Equitable spatial distribution of healthcare services is essential to minimize geographic barriers to access, particularly in eye care to ensure timely delivery of refractive care, early diagnosis of ocular pathologies, and consistent follow-up [1]. Analyzing the geographic distribution of an aging population is crucial to evaluate the regional eye care burden based on local demographic demands [2]. The aim of this study is to evaluate the spatial patterns of eye care services in Latvia by analyzing the geographical distribution of healthcare facilities offering ophthalmology or optometry services. To ensure a comprehensive representation of the eye care services available to the Latvian population, Geographical Information System methods were used to analyze Latvian Health Inspectorate data regarding officially registered healthcare institutions and their branches (90%) employing ophthalmologists or optometrists, supplemented by locations where certified optometrists provide clinical care (10%). To evaluate the regional eye care burden of presbyopia, the facility-to-population ratio was analyzed alongside the proportion of the population aged 45+. The national average was 2.0 per 10,000 population (with an average 45+ demographic load of 49%), with regional values of 1.9 (50%) in Vidzeme, 1.5 (50%) in Kurzeme,1.6 (49%) in Zemgale, 1.6 (55%) in Latgale and 2.8 (48%) in Riga. The findings may serve as a basis for future healthcare resource planning and for improving the spatial accessibility of eye care services in Latvia.

Acknowledgement: University of Latvia Development Programme for High-Impact, project Nr. ZDA-LIP2025/10.

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Public Health Chall. 2024; 3:e213

Keywords: spatial distribution, eye care services, facility-to-population ratio

THE EFFECT OF DIFFERENT TEXT TYPES ON EYE MOVEMENT PARAMETERS IN READING

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Eye-tracking technology enables an objective measurement of cognitive processing and reveals the specific adaptations of reading strategies that occur when encountering different levels of text complexity. Despite the growing interest in eye-tracking research in various languages, studies examining the influence of linguistic text complexity on oculomotor behavior within the Latvian language context remain limited.

The aim of the current study was to assess eye movement parameters while reading 10 texts of different genres in Latvian language and to evaluate the relationship between text comprehension and oculomotor behaviour. The study was conducted within the framework of the MultiplEYE COST Action by recording eye movements of 41 participants with the Eyelink1000+ eye tracking system.

The preliminary results reveal statistically significant differences in eye movement parameters between different text types. While average fixation duration showed a marginal negative tendency in relation to comprehension scores, it was observed that other oculomotor measures did not serve as significant predictors of the participants' understanding of the text.

The current findings indicate that eye movement parameters are sensitive to text characteristics, although this relationship is not linear and does not directly predict comprehension outcomes. The results also suggest the importance of considering individual differences in reading strategies, motivation, and language skills when interpreting eye movement data.

The study was conducted with the support of the Latvian Council of Science Fundamental and Applied Research Program, project No. lzp-2025/1-0195, and within the framework of COST Action No. CA21131.

Keywords: eye movements, reading, fixations, regressions, text comprehension

Poster Session 2: Optical Materials

DESIGN AND FABRICATION OF A POLARIZATION-MAINTAINING MODE FIELD ADAPTER USING THE LDS SYSTEM

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A mode field adapter (MFA) is an optical component designed to match the mode field diameters of two fibers with differing core sizes. A common configuration involves adapting a single-mode fiber to a large mode area (LMA) fiber to ensure efficient light transmission. MFAs are essential in high-power fiber lasers and amplifiers, where signals must be injected into fibers with larger effective mode areas [1].

This study focuses on the fabrication of a polarization-maintaining (PM) MFA, connecting a PM980-XP fiber to a PLMA-GDF-20/400-M fiber. Beyond minimizing insertion loss, the primary objectives included preserving the polarization state and maintaining single-mode operation. The research aimed to determine the adapter parameters through theoretical analysis and simulations, subsequently fabricating a physical component with performance aligned with these predictions.

The MFA was fabricated using fiber tapering and fusion splicing techniques, utilizing a Large Diameter Splicing (LDS) system. The design process comprised three stages: analytical estimation of MFA parameters, light propagation simulations and practical implementation. Through iterative optimization of the LDS system settings, an MFA with 80% transmission was achieved. This result is consistent with simulation findings, which predicted a maximum transmission of 86%. Further refinement of the fabrication process is proposed as a means to minimize the deviation between simulated and experimental results.

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Keywords: mode field adapter, polarization-maintaining fibers, fiber tapering, fiber lasers and amplifiers

EFFECT OF ANNEALING ATMOSPHERE ON OXYGEN VACANCIES FOR PURE AND DOPED HAFNIUM DIOXIDE

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Oxygen vacancies play a crucial role in determining structural and electrical properties of hafnium dioxide (HfO_2), especially in doped systems intended for ferroelectric applications. Full impact which different annealing atmospheres have on both vacancy formation and phase of the material is not yet fully understood. In this work, we investigate the effect of vacuum, oxygen and reducing (5% H_2) atmospheres on oxygen vacancy concentration and properties in pure and doped HfO_2 (Al, Y, Si). Samples were annealed at 500 °C for 8 hours under each atmosphere. Structural and defect-related changes were analyzed using X-ray diffraction (XRD), thermally stimulated luminescence (TSL), and X-ray photoelectron spectroscopy (XPS). Study aims to determine how different atmospheres influence oxygen vacancy formation, properties and the effects of suppression of formation when annealed at oxygen-rich environments. These findings provide insight into defect engineering in HfO_2 and support the functional properties optimization for electronic and ferroelectric applications.

IMPACT OF STRESS-APPLYING PARTS ON CLEAVE ANGLE CONSISTENCY IN POLARIZATION-MAINTAINING FIBERS

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High-performance optical systems require repeatable Polarization-Maintaining (PM) fiber cleaves with an angle <0.5° to ensure low insertion loss and polarization extinction ratio [1]. Standard mechanical cleaving often fails due to Stress-Applying Part (SAP), which introduces anisotropic stress and causes defects such as hackles, chips, and lips [2]. This study evaluates the tension-and-scribe method, where axial tension controls crack propagation and end-face perpendicularity.

We optimized the cleaving process for PM1550-XP fiber using a tension-based tool, and cleave quality was assessed via interferometric profiling (ProCleave and ProView, NorthLab). Axial tension (180–220 g) was tested across multiple SAP orientations to test whether external tension can overcome internal stress anisotropy.

Results show that standard tension settings for non-PM fibers are insufficient for PM fibers [3]. While guidelines allow angles up to 2° [2], our method achieved angles <0.3°, independent of SAP orientation. This confirms that precise tension control enables orientation-independent cleaving in advanced PM fiber applications.

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Keywords: Polarization-Maintaining fibers, Tension-and-Scribe Cleaving, Axial Tension, Stress-Applying Parts, Cleaving Optimization

LOW-COST INNOVATIVE ION IMPLANTATION APPARATUS CHALLENGES AND SOLUTIONS – ION PHYSICS, VACUUM, ELECTRONICS

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Doping of semiconductor and non-semiconductor materials is multi-billion worth technology worldwide, statistics shows that 70% of its market value are small R&D companies needing implantation for concept proof or small-scale manufacturing. Yet in the manufacture machinery markets may find any multi-million pieces large productivity implantator and none for small business scale where tens or hundreds of copies of products are needed. So, at 2019 was won the ERDF funding for research in this field so may clarify the outcomes.

1) Most popular but difficult dopant is boron, as it has extra high evaporation temperature. Thus, the ordinary ion gun is unable to make a boron rich plasma, except using the hardly toxic boron hexafluoride. We solved this problem toward use of pure boron, using combinate warm HC+ICP discharge and carbon electrodes.

2) Classically magnetic filter is industry standard for elimination of beam impurities. It is large, heavy and expensive. We shifted it by RF-QMS filter with success.

3) Doping industry is sensitive about purity. Industry standard demands to shift AISI vacuum recipients toward molybdenum, what is extra expensive solution. We find a good solution for this problem into quartz-glass.

4) Most of problems we got at electronics, where no ready-made blocks were easy to obtain. It refers to PC-drivable SMPS, safe galvanic insulation of 100 kV. We used a battery based surplus energy source to solve this capitally. Last but no least was problem of too complicated experimentation on totem pole compensation checkups after output transistor bridge. We solved this by introducing a Dirac-delta generator into steerable dummy load thus having a response curve in the one single flash.

Keywords: Boron ion source, low-cost implanter, electronic power sources, Dirac delta testing

MEASUREMENT OF THE OAM OF ROTATING VORTEX-LATTICES PRODUCED BY AN EXCITON-POLARITON CONDENSATE

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Exciton-polariton condensates can lead to a variety of pattern-forming behaviors, with the spontaneous formation of rotating vortex lattices among them. They are driven by the instability of high-angular-momentum modes in harmonically confined systems. Such non-stationary vortex lattices carry complex orbital angular momentum that is difficult to measure due to their rotation [1]. In this work, we present a testing platform that utilizes a spatial light modulator (SLM) to simulate the rotating vortex lattice. Further, we introduce a second SLM that analyzes the generated fields and provides an experimental tool to characterize its OAM content. The proposed method uses a Dammann vortex grating [2] and provides simultaneous multi-order OAM decomposition in a single measurement, taking advantage of the time-integrated nature of this technique.

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Keywords: Exciton-polariton condensates, orbital angular momentum, spatial light modulator

SYNTHESIS OF CU, AG, AND AU NANOPLATES FOR IN SITU SEM STUDIES OF THERMAL, ELECTRICAL, AND PLASMONIC HEATING

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Abstract: Silver (Ag), gold (Au), and copper (Cu) nanoplates are attractive materials for nanoelectronics and plasmonics due to their high electrical conductivity and pronounced localized surface plasmon resonance. For their reliable integration into functional devices, it is important to understand their morphological stability and melting behaviour under different excitation conditions. This work focuses on the synthesis of nanoplates and their preparation for in situ scanning electron microscopy (SEM) studies under thermal, electrical, and laser-induced excitation. Au nanoplates were synthesized by a chemical reduction self-seeding method using hydrogen tetrachloroaurate tetrahydrate, cetyltrimethylammonium bromide, and L-ascorbic acid. Ag nanoplates were prepared via selective reduction of the silver ammine complex using silver nitrate, sodium chloride, polyvinylpyrrolidone, ammonium hydroxide, and hydrogen peroxide. Cu nanoplates were synthesized from copper(II)chloride dihydrate using sodium iodide. The morphology and size distribution of the synthesized nanoplates were evaluated by SEM. The obtained nanoplates are currently being used in in situ SEM experiments to investigate their melting behaviour under three excitation modes: uniform thermal heating, current-induced Joule heating, and laser-induced plasmonic heating. These experiments enable direct observation of morphological evolution and melting-related transformations. Preliminary observations indicate that the transformation kinetics and morphological pathways depend strongly on both the material and the excitation mode. The study provides a basis for understanding the excitation-specific stability limits of metallic nanoplates and their potential use in nanoscale devices.

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Keywords: Nanoplates, SEM, silver, gold, copper

PHOTONIC ZITTERBEWEGUNG IN LIQUID CRYSTAL OPTICAL MICROCAVITIES

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We studied an experimental implementation of the photonic Zitterbewegung effect in liquid crystal optical microcavities. Photonic wave packets in our setup exhibited a characteristic oscillatory motion analogous to massive relativistic particles with spin, described in the literature as Zitterbewegung (ZB).

In our experiment, we observed this oscillatory motion of the light intensity maximum position, accompanied by a precession of its polarisation. Our results confirmed a direct correspondence between the respective periods of the propagating wave packet's trajectory and the changes in its polarisation, which had not yet been reported in literature.

An advantage of our setup is the tunability of the oscillations: the amplitude and period can be controlled by changing the refractive index of the liquid crystal inside the microcavity through applying an external voltage.

In addition, the oscillation amplitude and period varied for different perpendicular wave vectors of the incident beam (k). This finding indicates that the splitting of TE and TM modes in the cavity, which introduces an explicit k-dependence, should be included in the full description of the effect, despite having been neglected in previous experimental works [1].

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Keywords: Zitterbewegung, liquid crystal, microcavities

METAL HIGH REFLECTIVE MIRRORS FOR SPACE APPLICATIONS

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Nowadays, there is increased interest in small satellites, partly connected to the global secured quantum network There is increasing an interest to optical components that might be used in Space Space optics encompasses the technologies and principles related to using light and other forms of electromagnetic radiation in space based applications It involves the design, development, and use of optical systems for tasks like Earth observation, astronomy, and free space optical communication Due to solar activity, intense fluxes of high energy protons are formed, bombarding every object including optical equipment in their path Coatings must be prepared and tested to withstand further mentioned particle fluxes and energies encountered in earlier space missions.

Keywords: metal mirror, high-reflective coating, space communication, additive manufacturing

PLASMONIC SILVER NANOPARTICLES: SYNTHESIS AND OPTICAL RESPONSE

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Controlled synthesis of plasmonic silver nanoparticles (AgNPs) provides precise adjustments of they optical properties for advanced photonic and plasmonic application. Plasmonics is the study of how light interacts with free electrons in metals at the nanoscale, producing surface plasmons that strongly concentrate electromagnetic fields near the particle. AgNPs were produced via chemical route with well-defined morphology and characterizes using SEM. UV–Vis spectroscopy showed distinct surface plasmon resonance peaks whose positions correlate with particle size and shape, demonstrating how plasmonic behavior can be engineered for photonic device integration. These findings highlight the potential of plasmonic nanostructures for enhanced optical sensing and nanoscale light manipulation.

Keywords: Nanoparticle synthesis, nanomaterials, plasmonic.

SINGLE-PHOTON BLOCKADE AND SQUEEZING IN A DRIVEN HYBRID OPTOMECHANICAL SYSTEM

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We consider a hybrid quantum system consisting of a two-level atom (qubit) embedded in a superconducting microwave resonator (SMR). The SMR is capacitively coupled to a quantum micromechanical resonator (QD). Through a balanced linear transformation of the photonic and phononic fields, we define hybrid photon-phonon supermodes and investigate the system's nonlinearity, which primarily arises from the interaction between the qubit and the mode a. Nonclassical states of light are a central topic in quantum optics and play an important role in the study of quantum correlations and quantum information processing. In this work, we focus on the emergence of single-photon blockade. We analyze the second-order correlation function $g^{(2)} (0)$ and identify the parameter regimes in which the blockade is most pronounced, corresponding to the minimum of $g^{(2)}(0)$.

We show that photon and phonon blockade can be analyzed in modes a and b. Nevertheless, we demonstrate that blockade can emerge or be significantly enhanced in the hybrid mode c due to its mixed photonic–phononic character, even when it is absent in modes a and b.

Subsequently, we extend our analysis to nonclassical state characterization and quantum noise reduction. We demonstrate the emergence of squeezing and principal squeezing and identify parameter regimes in which the quantum noise is suppressed below the vacuum level, as evidenced by the squeezing and principal squeezing variances.

These results indicate that the hybrid nature of the mode enables the generation of robust quantum correlations, making the system a promising platform for the design of hybrid quantum interfaces.

Keywords: single-photon blockade, squeezing, nonclassical states, driven hybrid system

Poster Session 3: Laser Physics & Spectroscopy

DESIGN OF AN ENVIRONMENTALLY CONTROLLED CHAMBER FOR ULTRAFAST SOLID-STATE LASERS

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Building and operating ultrafast solid-state lasers requires precise optical alignment. They are highly sensitive to small environmental changes which can disrupt the mode-locked state. Temperature shifts cause the resonator to expand and alter its dimensions, while variations in humidity make it difficult to establish and maintain mode-locking. Since it is nearly impossible to fully control a typical laboratory room, the best approach is to isolate the laser in a custom-designed chamber where the immediate environment can be easily controlled. In this work, we present a complete workflow for designing such chamber. The process begins in resonator design software, where we simulate the laser and determine the optical layout, including mirror distances and beam sizes. This theoretical layout is then transferred into CAD software, where we physically model the mirrors on kinematic mounts and arrange all other necessary components. Based on this, we define the exact physical dimensions of the surrounding chamber. Finally, we design the chamber features, incorporating modular connections for cables and optical fibers, as well as integrated cooling channels for temperature control. Throughout the design process, all mechanical features are adapted to meet the practical constraints of CNC manufacturing. Ultimately, this workflow provides a clear path from simulation to a fully manufacturable chamber, ensuring a stable environment where the laser will be constructed and operated.

Keywords: ultrafast, chamber, laser, solid-state, cr:zns, cad

ENHANCED METHODOLOGY FOR PRECISE SPLICE OPTIMIZATION OF ACTIVE ER-DOPED PM FIBERS

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Advanced fiber lasers and amplifiers require low-loss splices between active and passive polarization-maintaining (PM) fibers to maximize optical efficiency [1, 2]. This study evaluates arc splicing parameters for Er-doped PM fibers (4 µm and 8 µm core) and passive PM fibers (PM1550-XP, PM980-XP) across four splicer models (Fujikura FSM-100P, FSM-100P+, Fitel S185, Fitel S183PM).

Initial cut-back optimization (at 1311 nm) showed a significant correlation between transmission loss and active fiber length, due to background absorption. To eliminate this measurement error, the new approach was implemented, involving precisely cleaving the active fiber to a length of only a few millimeters immediately after the splice.

Short-cleave measurements showed that standard optimization gains were artifacts caused by active fiber-length variations. While default manufacturer parameters were generally optimal, specific adjustments yielded a ~2 percentage-point increase in transmission gain, exceeding 97% efficiency. The study concludes that rigorous minimization of doped fiber length is essential for accurate splice evaluation.

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Keywords: Fiber Splicing, Active Fibers

ENVIRONMENTAL MONITORING SYSTEM WITH HUMIDITY CONTROL FOR OPTOELECTRONIC APPLICATIONS

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Mode-locked lasers based on Cr:ZnS gain crystals emit broadband mid-infrared radiation, which may cover a spectral range with significant water vapour absorption around the wavelength of 2.7 μm. Therefore, to achieve stable laser operation, the fluctuations of relative humidity (RH) in the laser environment must be reduced to a minimum. This project addresses this issue by developing an integrated system for environmental monitoring and active humidity control. The primary objective was to design, implement and validate a system capable of achieving and maintaining stable, low-RH levels within an experimental chamber. Secondary objectives included controlling selected actuators within the chamber, collecting data on dehumidifier membrane power parameters and implementing a server-based system for visualising and archiving data from multiple chambers.

The research included selecting various components such as SHT35 sensors, a PEM membrane, an ESP32 microcontroller and relevant software, taking into consideration the limitations and objectives. Further validation was conducted during and after assembly. The resulting system demonstrates effective stabilization of humidity at 25% RH within 150 minutes and reaching as low as 11% RH during extended operation. This, combined with the control server, constitutes an effective system for supporting other optoelectronic experiments and research by improving the accuracy and repeatability and by streamlining the environmental control.

Keywords: Humidity, mid-IR Lasers, regulation, enviromental control

SIMPLIFYING PULSE OPTIMIZATION FOR MULTIPHOTON IMAGING VIA ALGAAS DIODE-BASED PEAK POWER DETECTION

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Multiphoton imaging relies on nonlinear excitation processes such as two-photon absorption, making it highly sensitive to the peak intensity of ultrashort laser pulses and requiring precise temporal compression. In practice, pulse compression is optimized by maximizing nonlinear signals such as second-harmonic generation (SHG), which serve as an intensity-dependent feedback but require careful alignment and additional optical components. Here, we explore a simplified approach to peak power monitoring based on AlGaAs semiconductor devices operated in a reverse-illumination configuration, investigating laser diodes and light-emitting diodes as potential detectors exploiting nonlinear absorption in the material.

We compare the nonlinear response of the investigated devices with a conventional SHG-based scheme and demonstrate their use in an adaptive pulse compression loop. Both devices exhibit a nonlinear response, enabling their use as feedback signals for pulse optimization. These results indicate that AlGaAs-based detectors can provide a compact and less alignment-sensitive alternative to SHG, while offering polarization-insensitive operation and reduced sensitivity to ambient light conditions, facilitating pulse optimization in practical multiphoton imaging systems.

Keywords: multiphoton imaging, pulse optimization, peak power detection, AlGaAs diodes, femtosecond pulses

GAIN MEDIUM ELECTRO-OPTICAL MODULATION FOR CARRIER-ENVELOPE OFFSET FREQUENCY STABILIZATION

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At the forefront of modern photonics is the control of light in its shortest form - the laser pulse. By stabilizing the repetition frequency (f) and carrier-envelope offset frequency (f), a pulsed laser becomes an optical frequency comb, enabling applications such as attosecond science, optical clocks, molecular spectroscopy, and exoplanet detection. While f stabilization is commonly achieved via pump modulation, this approach is fundamentally limited by the gain medium's fluorescence lifetime. Alternative techniques, including loss and phase modulation, extend bandwidth but increase system complexity. Here, we introduce a novel approach based on electrooptic modulation of the gain medium itself. We demonstrate that chromium-doped ZnS (Cr:ZnS) exhibits voltage-induced rotation of the optical axis, allowing the gain crystal to simultaneously act as a polarization modulator for direct f control. The method is implemented in a Kerr-lens modelocked Cr:ZnS oscillator operating near 2.3 µm. While electro-optic relaxation high-passes the modulation bandwidth of Cr:ZnS to ~40 Hz, we overcome this by combining gain-medium modulation with a loose lock provided by pump modulation for long-term stabilization. This hybrid approach enables stable locking of f and results in the integrated phase noise of 13 mrad (1 Hz –1 MHz).

These results establish gain-medium electro-optic modulation as a powerful and compact solution for solid-state optical frequency comb stabilization.

Keywords: solid-state laser, fceo stabilization, electro-optic modulation

SPECTRAL WIDTH OPTIMIZATION OF THE INFRARED CONTINUUM GENERATED BY A FEMTOSECOND ERBIUM-DOPED FIBER LASER AND A NONLINEAR SILICA FIBER

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Supercontinuum extending from 940 nm to 2600 nm is generated in an all-fusion-spliced silica nonlinear fiber system pumped at 1560 nm by a femtosecond erbium-doped fiber laser. The femtosecond source was first characterized as a function of input and output fiber length, yielding approximately 30 fs pulses with 236 mW average power in single-pump operation. The nonlinear fiber system consists of a short length of highly nonlinear germano-silicate fiber spliced to a silica fiber section. The HNLF length was varied from 11 cm to 2 cm to investigate its influence on the spectral bandwidth, flatness, and power distribution of the generated continuum. The HNLF provides the initial nonlinear broadening stage through higher-order soliton compression, self-phase modulation, Raman-induced soliton dynamics, and dispersive-wave generation before propagation in the silica fiber. Shorter HNLF sections are shown to improve the spectral flatness of the infrared continuum, while the generated bandwidth remains strongly dependent on the nonlinear interaction length. The fully spliced configuration provides a compact and mechanically stable broadband source covering the near- and short-wave-infrared regions.

Keywords: supercontinuum generation, femtosecond laser, infrared

THERMO-OPTIC PHASE SPECTROSCOPY (TOPS), A NEW METHOD FOR MEASURING THERMAL CONDUCTIVITY IN SOLID MATERIALS

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Light-emitting diodes (LEDs) utilizing novel semiconductor materials are continuously optimized for peak efficiency. As electrical and optical losses decrease, thermal management has become the primary challenge. Heat dissipation in electronic devices raises operating temperatures, which directly reduces efficiency and device lifespan [1]. However, the rough surfaces typical of many organic materials hinder Time-Domain Thermoreflectance (TDTR) method that require perfectly smooth interfaces.

The thermo-optic phase spectroscopy (TOPS) method measures small changes in the path of reflected light caused by local temperature increases. This technique is based on a pump-probe architecture: uses a modulated pump laser to induce periodic heating and localized physical deformation via the material's thermal expansion coefficient [2]. A probe laser then tracks these changes using a quadrant cell photodetector. Compared to the TDTR method, TOPS offers higher signal-to-noise ratio and greater probing depth. This is because the signal depends on the beam radius of the focused pump and probe [3], as well as the beam offset, that can be precisely tuned using suitable optical components.

TOPS analysis, can determine the material's in-plane diffusivity, which correlates with thermal conductivity and heat capacity. This method allows for the mapping of thermophysical properties in new materials, allowing design of more efficient electronic devices.

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Keywords: Photothermal spectroscopy, Optical thermometry, TOPS, Thermal properties, Thermal conductivity

Poster Session 4: Biophotonics

DEVELOPMENT OF ARTIFICIAL SALIVA FOR OPTICAL APPLICATIONS

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Human saliva provides valuable information that allows for quick and safe medical actions [1]. Currently used diagnostic methods are often invasive, time-consuming, and resource-intensive [2]. As a result non-invasive and highly accurate methods based on fiber optic biosensors are gaining particular popularity [3,4].

One promising approach is the use of phantoms, which are artificial materials that mimic the properties of real human body fluids [5]. Artificial saliva enables the testing of diagnostic methods in a safe and controlled manner, without relying on clinical material. Current formulations are often complex and fail to accurately replicate the optical properties of saliva, which are highly dependent on the preparation process [6].

This research presents a development of artificial saliva for evaluating optical diagnostic methods. The proposed phantom is characterized by a simple formulation using well-known and available substances, making it a promising and replicable testing medium. Measurements conducted using UV-Vis spectroscopy confirmed that the developed phantom mimics the real saliva in the 210–240 nm range for the highest peak at 222nm with up to 90% accuracy.

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Keywords: optical phantoms, artificial slaiva, opical properties, fiber optics biosensor

MACHINE LEARNING-DRIVEN OPTICAL BIOSENSING FOR INFLUENZA RNA DETECTION IN WASTEWATER

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Monitoring Influenza RNA in municipal wastewater is a critical component of early-warning epidemiological surveillance. However, stochastic noise and baseline drifts in raw sewage often mask the analytical signal, challenging traditional statistical methods. Here, we present a fiber-optic biosensing platform enhanced with machine learning for viral RNA detection in untreated wastewater.

Integrating a fiber-optic microsphere sensor with Discrete Wavelet Transform (DWT) and a Random Forest framework, the system detects target RNA down to 0.1 fM. Our results show a significant predictive improvement over traditional methods. While simple linear regression failed to model viral load (R2 = -2.091), the proposed framework achieved R2 = 0.877 (95% CI: 0.796–0.938) and 98.1% binary classification accuracy. Reproducibility and predictive stability were assessed via Nested Leave-One-Out Cross-Validation, with cross-session generalization identified as a direction for future validation.

Explainable AI (SHAP) analysis confirms the model's decisions are physically grounded, targeting high-frequency wavelet perturbations associated with RNA hybridization on the microsphere surface. The effective analytical window spans three orders of magnitude (0.1-100 fM), with performance degradation at 1000 fM consistent with potential receptor saturation. This sensing framework advances wastewater-based epidemiology, providing a complementary tool for public health infrastructure.

Keywords: Remote wastewater surveillance, Fiber optic sensor, Wavelet transform, Influenza RNA, Machine learning

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