AOP 2026

7TH INTERNATIONAL CONFERENCE ON APPLICATIONS OF OPTICS AND PHOTONICS

Book of Abstracts

Lisbon, Portugal, July 7-10, 2026

Preliminary Version

ORGANIZATION

IN COOPERATION WITH

SUPPORT / ENDORSEMENTS

Version: July 9, 2026

Venue:
Instituto Superior de Engenharia de Lisboa,
Rua Conselheiro Emídio Navarro, 1
1959-007 Lisboa, Portugal

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Track Codes

Code	Track Description
BIOOPTPH	Biomedical and Medical Applications of Optics and Photonics
ENSSC	Energy, Sustainability and Smart Cities
INTPH	Integrated Photonics
LNOPT	Lasers and Nonlinear Optics
MATPRCH	Materials Processing and Characterization
NANPHOPT	Nano-photonics and Optoelectronics
O3CVS	Optometry, Ophthalmic Optics, Color and Visual Sciences
OPTCOM	Optical Communications
OPTFSA	Optical Fibers, Sensors and Applications
OPTINSTSA	Optical Instrumentation for Space and Astronomy
OPTMAT	Optical Materials
OPTMETIMP	Optical Metrology, Image Processing and Industrial Applications
PPV	Photonics for Photovoltaics
QOPT	Quantum Optics
THEOCOMPOPT	Theoretical and Computational Optics

Presentation Time Allocation

Presentation Type	Talk	Q&A	Total
Plenary	40 min	5 min	45 min
Keynote	25 min	5 min	30 min
Invited	15 min	5 min	20 min
Oral	12 min	3 min	15 min

Day	Time	Event Type	Room
Tuesday, July 7	09:00 12:30	Registration	Foyer
	12:00	Lunch	
	13:45	Opening Ceremony	Auditorium
	14:45	Plenary Session 1 [LNOPT]	Auditorium
	15:30	Plenary Session 2 [INTPH]	Auditorium
	16:15	Coffee Break	
	17:00	Parallel Session 1 [INTPH1]	Auditorium
	17:00	Parallel Session 1 [OPTMETIMP1]	Maxwell Room
	17:00	Parallel Session 1 [BIOOPTPH1]	Fresnel Room
	18:30	Welcome Reception and Poster Session 1	Main Hall
	20:00	End of the day	
Wednesday, July 8	08:00	Registration	Foyer
	08:45	Plenary Session 3 [INTPH]	Auditorium
	09:30	Parallel Session 2 [INTPH2]	Auditorium
	09:30	Parallel Session 2 [OPTMETIMP2]	Maxwell Room
	09:30	Parallel Session 2 [NANPHOPT1]	Fresnel Room
	11:00	Coffee Break	
	11:30	Parallel Session 3 [BIOOPTPH2]	Auditorium
	11:30	Parallel Session 3 [OPTMETIMP3]	Maxwell Room
	11:30	Parallel Session 3 [THEOCOMPOPT1]	Fresnel Room
	13:00	Lunch	
	14:30	Parallel Session 4 [BIOOPTPH3]	Auditorium
	14:30	Parallel Session 4 [OPTFSA1]	Maxwell Room
	14:30	Parallel Session 4 [O3CVS1]	Fresnel Room
	16:00	End of Sessions	
	17:00	Social Program - Visit to Mosteiro de São Vincente	
	19:00	Conference Dinner	Voz do Operário
	23:00	End of the day	

Day	Time	Event Type	Room
Thursday, July 9	08:00	Registration	Foyer
	08:45	Plenary Session 4 [LNOPT]	Auditorium
	09:30	Parallel Session 5 [OPTFSA2]	Auditorium
	09:30	Parallel Session 5 [OPTINSTSA1]	Maxwell Room
	09:30	Parallel Session 5 [QOPT1]	Fresnel Room
	11:00	Coffee Break	
	11:30	Parallel Session 6 [OPTFSA3]	Auditorium
	11:30	Parallel Session 6 [OPTMAT1]	Maxwell Room
	11:30	Parallel Session 6 [QOPT2]	Fresnel Room
	13:00	Lunch	
	14:30	Plenary Session 5 [PPV]	Auditorium
	15:15	Parallel Session 7 [PPV1]	Auditorium
	16:00	Parallel Session 7 [ENSSC1]	Auditorium
	15:15	Parallel Session 7 [NANPHOPT2]	Maxwell Room
	15:15	Parallel Session 7 [LNOPT1]	Fresnel Room
	16:45	Poster Session 2 and Coffee Break	Main Hall
	18:15	SPOF General Assembly	
	20:00	End of the day	
Friday, July 10	08:00	Registration	
	08:45	Plenary Session 6 [MATPRCH]	Auditorium
	09:30	Parallel Session 8 [MATPRCH1]	Auditorium
	09:30	Parallel Session 8 [OPTCOM1]	Maxwell Room
	09:30	Parallel Session 8 [OPTINSTSA2]	Fresnel Room
	10:50	Coffee Break	
	11:10	Parallel Session 9 [MATPRCH2]	Auditorium
	11:10	Parallel Session 9 [OPTCOM2]	Maxwell Room
	11:10	Parallel Session 9 [OPTFSA4]	Fresnel Room
	12:30	Awards & Closing Ceremony	
	13:00	Lunch	
	14:30	Guided Tour to RTP Museum	

Tuesday, July 7

09:00 12:30 **Registration** *Foyer*

12:00 **Lunch**

13:45 **Opening Ceremony** ***Auditorium***

President of IPL, Prof. António Belo
President of ISEL, Prof. José Manuel Peixoto Nascimento
President ICO, Dr. Eric Rosas
President EOS, Prof. Ignacio Moreno
President RIAO, Prof. Maria Sagrario Millan Garcia Varela
President SEDOPTICA, Prof. Maria Teresa Flores Arias
President SPF, Prof. Pedro Morais Teixeira de Abreu
Sponsor Pitch: ERT-OCEAN OPTICS
President SPOF/AOP2026 Chair, Prof. Manuel Filipe Costa
Local Committee, Prof. Paula Louro

14:45 **Plenary Session 1 [LNOPT]** ***Auditorium***

Chair: Manuel F. M. Costa (University of Minho)

203 Precision Optical Spectroscopy of Magnetoelectric Interactions in Quantum Materials – *Edoardo Baldini*

15:30 **Plenary Session 2 [INTPH]** ***Auditorium***

Chair: Manuel F. M. Costa (University of Minho)

280 Photonic Computing & Applications – *Bhavin Shastri*

16:15 **Coffee Break**

17:00 **Parallel Session 1 [INTPH1]: Reconfigurable Photonic Integrated Circuits** ***Auditorium***

Chair: Marco Piccardo (IST)

110 Phase-Change Materials as an Enabling Platform for Memory-Enabled Silicon Photonics – *Bharathi Rajeswaran* - (Invited)
48 Computational Design of a TE/TM-Pass Polarization Controller on SOI Photonic Integrated Circuits – *Kenan Cicek*
56 A Reconfigurable Free-Space Optical Fabric for Chip-to-Chip Interconnects – *John Sanford*
283 3D printing of optical interconnects for PICs – *Alexander Legant (Nanoscribe)*

17:00 **Parallel Session 1 [OPTMETIMP1]: High-Speed Photonic, Quantum, and AI-Enabled Optical Systems** ***Maxwell Room***

Chair: Sandra Franco (University of Minho)

126 High-speed trace gas detection based on all-optical pattern matching using precise phase control of an optical frequency comb – *Kaoru Minoshima* - (Keynote)
95 A Gigahertz Thin-Film Lithium Niobate Phase-SLM Architecture for True Matrix–Matrix Multiplication in Photonic AI Accelerators – *Eran Gur*
144 Adaptive Lighting Control System for Automotive Headlights Based on Computer Vision – *Enrique Sánchez del Ángel*

17:00 **Parallel Session 1 [BIOOPTPH1]: Advanced Optical Imaging and Microfluidic Platforms for Biophotonics** ***Fresnel Room***

Chair: Nélia Alberto (IT-Aveiro)

68 Light Sheet Fluorescence Microscopy for Biophotonics – *Alessia Candeo* - (Invited)
76 Holographic endoscopy: challenging the limits of conventional imaging – *André Gomes* - (Invited)
270 Microfluidics model to analyze formation of intracranial aneurysm: fabrication challenges with optical technologies – *Carmen Bao Varela* - (Invited)

18:30 Welcome Reception and Poster Session 1 ***Main Hall***

BIOOPTPH

99 Digital Holographic Microscopy for Tissue Analysis across Malignancy Grades: A Label-Free Approach to Cancer Diagnostics in Digital Pathology – *Violeta Liuba Calin*
111 From Bacterial Fingerprints to Renal Biomarkers: Deep Learning in Raman Spectroscopy – *Rima Mansour*
132 Fabrication and structural characterization of dexamethasone-loaded SZ2080 structures via two-photon polymerization – *Marta Rodriguez-Lorenzo*
133 Dimensionality reduction in hyperspectral profiles classification of cells from serous cavities – *Violeta Liuba Calin*
134 A Single-Stage Approach to Dynamic Focusing for High-NA Full-Field OCT – *Taylor Sanderson*
135 Acute Kidney Injury/Chronic Kidney Disease diagnosis through Optoelectronic-based urine analysis – *Ana Moreno*
156 In Vitro Time-Correlated Near-Infrared Photon Counting for Direct Detection of Singlet Oxygen in 5-ALA-Sensitized Glioblastoma Cells – *Iva Popović*
160 Label Free TCMPC Quantification of Singlet Oxygen Phosphorescence in 5 ALA PDT Glioma Models – *Maja Nesic*
166 Light-based analysis of voice frequency – *Nelia Alberto*
182 Fiber Bragg gratings in PDMS membranes for real-time respiratory monitoring using edge filtering – *Eduarda Marinho*
215 Carbon dot-based optical sensor for ferritin detection: preliminary insights – *Nelia Alberto*
235 Optimization of Machine Learning Algorithms for Color Prediction in Anatomically Shaped Resin-Based Dental Materials: A Pilot Study. – *Maria Tejada Casado*
244 Chromatography-on-a-chip: UV-VIS detection using miniaturized amorphous silicon photosensors – *Rodolfo G. Rodrigues*
248 Estimation of the Electric Dipole Moment in the First Excited State of Trypan Blue Molecule from Solvatochromic Data – *Mihaela Miron*
263 Photonic integrated circuit for Salmonella species determination – *Sara Costa*
269 Outdoor Evaluation of Low-Resolution LiDAR Representations for Assistive Obstacle Detection – *Nuno Bezelga*

INTPH

49 Development of an all optical 1 X 4 switch – *Paulo Lourenço*
141 Reconfigurable Optical Switching using Sb2Se3 Phase-Change Material – *Iñigo Lopez-Mulet*
253 Silicon Nitride Ring Resonator Simulation for Visible-Band Integrated Photonics – *Martim Lemos*
260 Graphene Based Modulator – *Diogo Martins*
274 Optimization of Optical Coupling from Free Space to Photonic Waveguides under Alignment and Turbulence Constraints – *Ileida Veiga*

OPTMETIMP

117 Experimental Techniques for Measuring MTF – *Héctor Aira*
137 YOLO Based Method for Defect Detection in Painted Surfaces – *João Fontoura*
138 Logistic Regression-Based Method for Defect Detection in Painted Surfaces – *Rodrigo Rito*
186 Integrated Software Tool for Batch 3D Reconstruction Using Fringe Projection Profilometry – *Juan Vilardy*
217 Optical Drone-Mounted Payload for In-Flight Detection of Airborne Microplastics – *Guilherme Pereira*
259 Optimization of Lens Design for Spot Size Stability Under Irregular Surface Topologies – *Diogo Martins*
262 Hierarchical Classification of Polymer Pellets using Short-Wave Infrared Hyperspectral Imaging for Recycling Applications – *Rui Carvalho*

NANPHOPT

46 Tuning Chemical Interface Damping in Single Au–Ag Heterostructured Nanodumbbells by Adjusting the Au–Ag Atomic Ratio and the d-Band Center Position – *Ji Won Ha*
113 Nanowires for Enhanced Biosensing: Tapered Geometry to Improve Fluorescence Signal and Imaging – *Farhana Akter Mou*
55 Broadband THz Polarization Conversion with All-Silicon Metasurface – *Rebeca Tudor*

THEOCOMPOPT

201 LIDAR beam steering via 2D amorphous silicon photonic optical phase controlled array – *Gabriele Farina*
242 Analysis of control mechanisms for directional-coupler-based 2×2 photonic switches in amorphous silicon waveguides. – *Ernesto Velazquez*

OPTMAT

90 Photonic Plasmonic Paper Platform for Multimodal Optical Sensing – *Caterina Serafinelli*
168 Azobenzene Relief Gratings for Reconfigurable Photonic Applications – *Paulo Ribeiro*

O3CVS

104 Modulation of Pupillary Constriction by Commercial LED: Effects of CCT and background Luminance – *Beatriz Martinez Matesanz*
105 Colour Temperature and Glare in Pseudophakic with Depth-of-Focus Lenses – *Isabel Arranz de La Fuente*
163 Ocular Optical Quality During Accommodation and Post-Stimulus Across Refractive States – *Sandra Franco*

20:00 End of the day

Wednesday, July 8

08:00 **Registration** *Foyer*

08:45 **Plenary Session 3 [INTPH]** ***Auditorium***
Chair: Manuela Vieira (CTS-ISEL)
264 Photonic Interfaces for Weak Dynamics in Nature – *Imran Avci*

09:30 **Parallel Session 2 [INTPH2]: Integrated Photonics: From PIC Design and Fabrication to Quantum Applications** ***Auditorium***
Chair: Alessandro Fantoni (CTS-ISEL)
251 Integrated Photonics for Quantum Applications – *Jorge Barreto* - (Keynote)
190 Industry-compatible, hands-on training modules for PIC design, fabrication, and testing – *Emre Kaplan* - (Invited)
62 A Photonic Journey: From Systems to Devices – *Senthil Vinodh*
187 How Luceda empowers the PIC value chain – *Ana Filipa Gonçalves de Carvalho*

09:30 **Parallel Session 2 [OPTMETIMP2]: Optical Spectroscopy and Sensing for Environmental, Material, and Food Analysis** ***Maxwell Room***
Chair: Paulo Tavares (University of Porto)
66 Photoacoustic Spectroscopy for Ambient Aerosols Characterization – *Abdul Rahman* - (Keynote)
207 Development of a multispectral spatially resolved light logger – *Francisco Afonso*
181 Overcoming the Limitations of Pd Thin Films in SPR Hydrogen Sensors with Au@Pd Nanoparticles – *Miguel A. S. Almeida*
153 Real-time temperature monitoring in a diode-pumped alkali laser via NIR methane absorption spectroscopy – *Fengjie Xi*

09:30 **Parallel Session 2 [NANPHOPT1]: Resonant Nanophotonics, Wave Control, and Photonic Computing** ***Fresnel Room***
Chair: João Pinto Coelho (University of Lisbon)
47 Controlled Suppression of Anderson Modes in a Three-Dimensional Disordered Optical Waveguide – *Belkıs Gökbulut*
52 Paired exceptional points and a q-BIC on a bulk Fermi arc in a single dielectric ring resonator – *Nikolay Solodovchenko*
169 Nanophotonic Resonant Tunneling Diodes for Neuromorphic Applications – *Francisco Várzea Figueiras*
210 Extreme Learning Machine in Artificial Sensory Oscillator Photonic Neurons – *Juan Silva*
243 Spatial Encoding and Multimode Fiber-Based Photonic Extreme Learning Machines for Efficient Optoelectronic Computing – *Pedro Miguel Sousa Coelho*

11:00 **Coffee Break**

11:30 **Parallel Session 3 [BIOOPTPH2]: Advanced Optoelectronic Sensing: From Quantum Technologies to Biomedical Diagnostics** ***Auditorium***
Chair: João Costa (CTS-ISEL)
96 Are Thin Film Devices Ready for Biomedical Optoelectronics? – *Domenico Caputo* - (Keynote)
255 Quantum sensing forever – *Jana Nieder* - (Keynote)
162 Calibration of a Time-Resolved Near-Infrared Detection System for Singlet Oxygen – *Mioljub Nesic*
236 Molecularly Imprinted Polymer-Based Dual-Transduction Biosensor for Albumin Detection: Toward Point-of-Care Monitoring of Hypertension Biomarkers – *Ana Sofia Matos Assunção*

11:30 **Parallel Session 3 [OPTMETIMP3]: Computational, Holographic, and Wavefront Imaging** ***Maxwell Room***
Chair: António Baptista (University of Minho)
61 Decoupling Imaging Geometry from Optics Using Digital Holography – *Claas Falldorf* - (Keynote)
174 Integrated 3D Imaging and Spectroscopy for Cultural Heritage Analysis – *Luana Pereira*
178 Polarization-Holographic Imaging Stokes Spectropolarimeter for Remote Sensing Applications – *Barbara Kilosanidze*

11:30 **Parallel Session 3 [THEOCOMPOPT1]: Computational Methods in Photonics, Metrology and Nanostructured Optics** ***Fresnel Room***
Chair: Paulo Lourenço (CTS-ISEL)

74 Characterizing Structured Polarizing Elements through Matrix-Based Fourier Optics – *Ignacio Moreno* - (Keynote)
102 Simulation of optical transmission through planar multilayer dielectric stacks on silicon substrates: a comparative analysis between three numerical approaches – *João Fernandes*
208 fastplasmon - A Python toolkit for fast computation of near and far-field quantities for plasmonic nanoparticles – *Paulo Santos*
226 Interactive interface Software for color evaluation – *Rafael Vázquez Conejo*

13:00 **Lunch**

14:30 **Parallel Session 4 [BIOOPTPH3]: Advanced Optical Imaging and Microfluidic Platforms for Biophotonics** ***Auditorium***
Chair: Domenico Caputo (La Sapienza University Rome)

276 Laser-based Technologies for the Advanced Fabrication of Organ-on-a-Chip Devices in Personalized Medicine – *Maria Teresa Flores Arias* - (Keynote)
78 Three-dimensional label-free imaging of rapid biological cell dynamics via interferometric multiplexing – *Natan T. Shaked*
232 Optically Triggered Plasmonic Lipogels for Precision Melanoma Treatment – *Valéria Gomes*
45 Effects of Skin Pores on Photon Propagation in Optical Brain Imaging Systems – *Kenan Nurettin Bilgiçer*
247 Solvatochromic Investigation and Quantum-Molecular Modeling of 9-Aminoacridine – *Mihaela Miron*

14:30 **Parallel Session 4 [OPTFSA1]: Applied Fiber-Optic Sensors for Monitoring and Human Interaction** ***Maxwell Room***
Chair: Marta Ferreira (i3N/UA)

67 From Ultralow-Concentration Biosensing to Vibrational Fingerprint Selectivity with Bound States in the Continuum Metasurfaces – *Silvia Romano* - (Keynote)
53 Multi-parametric fiber Bragg grating sensor to monitor users of a soft hand-exoskeleton – *Juan Andrés García Zapata*
171 Tactile sensor based on multicore fiber Bragg gratings – *Arezoo Sheykhian*
240 In Situ Monitoring of Critical Safety Parameters in Lithium-Ion Batteries via Hybrid Fiber-Optic Sensing – *Micael Nascimento*
254 Sensing Batteries via Optical Fiber Sensors: Operando Monitoring in-cell Refractive Index and Temperature – *Tiago Amaral*

14:30 **Parallel Session 4 [O3CVS1]: Ocular Optics, Imaging and Visual Performance** ***Fresnel Room***
Chair: Paula Louro (CTS-ISEL)

114 Precision sight: The Optics behind the intraocular lens – *Maria S. Millán García-Varela* - (Keynote)
230 Anterior segment OCT image features in the retro-iris space – *António Baptista* - (Invited)
119 Subclinical Ocular Effects of Digital Blue Light Exposure: An Integrated Optical and Functional OCT Study – *Vladimiro Hipólito*
164 Ocular optical quality in reduced accommodation: accommodative dysfunction vs pre-presbyopia – *Jessica Gomes*
245 Deriving Individualized Color Matching Functions in Color Vision Deficiency with a 3D-printed Colorimeter – *Rodrigo Lecanda Rodriguez*

16:00 **End of Sessions**

17:00 **Social Program - Visit to Mosteiro de São Vincente**

19:00 **Conference Dinner** ***Voz do Operário***

23:00 **End of the day**

Thursday, July 9

08:00 **Registration** ***Foyer***

08:45 **Plenary Session 4 [LNOPT]** ***Auditorium***
Chair: Paula Louro (CTS-ISEL)
69 Liquid Solitons in Photonic and Quantum Systems – *Humberto Michinel*

09:30 **Parallel Session 5 [OPTFSA2]: Advanced Fiber-Optic Devices, Distributed Sensing, and Optical Measurement Platforms** ***Auditorium***
Chair: Orlando Frazão (University of Porto)
149 High Transmission in Step-Index Multimode Fibre Tapers – *Piyamas Choochalerm*
250 Acoustic Detection and Source Localization with Event-Based Fiber Speckle Sensing – *Sofia Marques Duarte*
256 Going Around The Core: Ultra-Sensitive Refractometry Based on Cladding Multimode Interference – *Mariline Costa*
211 Innoaqua: Innovative Approaches for an Integrated use of Algae in Sustainable Aquaculture Practices and High-Value Food Applications – *João Mendes*

09:30 **Parallel Session 5 [OPTINSTSA1]: Optical Systems and Components for Space Applications** ***Maxwell Room***
Chair: Alexandre Cabral (University of Lisbon)
81 Reliability of opto-electronic components in space – *Heinz-Christoph Neitzert* - (Keynote)
184 Gallium oxide UV photodetectors for solar-blind and space applications – *Steve Reynolds* - (Invited)
97 Optical System Design and Performance Analysis of a Star Tracker – *Tuğba Güvercin*
93 PoET: a spatially resolved Sun in a high-resolution spectrograph – *Inês Leite*

09:30 **Parallel Session 5 [QOPT1]: Quantum Photonic Networks, QKD, and Secure Communication** ***Fresnel Room***
Chair: Miguel Fernandes (CTS-ISEL)
72 Quantum Photonic Chips for Quantum Entanglement Distribution Networks – *Wei Zhang* - (Keynote)
94 Single-Photon Detectors for Satellite-Earth QKD Links – *Jaime Vieira*
147 High-Speed Lithium Niobate Polarization Control for Polarization-Encoded QKD – *Hugo Costa*
227 Experimental Bell Inequality Violation Using Constrained Measurement Geometry – *Piyush Saklani*
285 Analytical Modeling And Control Of Nonlinear Light–Matter Interactions In Ultracold Quantum Systems – *Mariam Gevorgyan*

11:00 **Coffee Break**

11:30 **Parallel Session 6 [OPTFSA3]: Advanced Optical Fiber Systems for Sensing, Metrology, and Communications** ***Auditorium***
Chair: Heinz C. Neitzert (University of Salerno)
22 Design of a Photonic Synopsis Multiplexer Based on Multicore Polymer Optical Fiber – *Dror Malka* - (Invited)
143 Exploring New Frontiers in Optical Interferometric Sensing: Vernier effect and White Light Interferometry for Harsh Environments – *Paulo Robalinho* - (Invited)
60 Emerging Trends in Optical Metrology for Optical Communication Systems. – *Modesto de Morais* - (Invited)
157 Integrated Sensing and Communications: Coexistence of a 400G Coherent Link and Raman-based Distributed Temperature Sensing at 1064 nm – *Joana Vieira*
228 Two Optical-Fiber Approaches to Embeddable Concrete Monitoring: Interferometric and Intensity-Based Methods – *Rita Pereira de Faria*

11:30 **Parallel Session 6 [OPTMAT1]: Functional and Active Photonic Materials** ***Maxwell Room***
Chair: Paulo António Ribeiro (Universidade Nova de Lisboa)
71 High-energy meta-optics for structured laser-matter interactions – *Marco Piccardo* - (Keynote)
185 CoherentStack: Modelling and Characterization of Optical Multilayer Structures Using the Transfer Matrix Method – *Yuriy Vygranenko*
58 Hybrid Metallic-Dielectric Systems for Sensitive Optical and Biological Detection – *Andrea Chiappini*

116 All-optical reservoir computing enabled by luminescent materials with intrinsic synaptic dynamics – *Ana Rita da Naia Bastos*
161 Enhanced Fluorescence-Based Sulfite Detection in Acidic Media with Platinum(II) Porphyrins – *Guilherme Costa*

11:30 **Parallel Session 6 [QOPT2]: Quantum Light Sources, Coherent Control, and Quantum-Enhanced Sensing** ***Fresnel Room***
Chair: Jana Nieder (INL)
73 Towards the quantum noise limit in mid-infrared Quantum and Interband Cascade Lasers – *Paolo de Natale* - (Keynote)
200 Beyond Single Lasers: 2-Dimensional VCSEL Arrays – *Kent Choquette* - (Keynote)
257 Quantum-based polarization imaging: from quantum to nonlinear interference – *Carolina Ramos Goncalves*
258 All-optical coherent quantum control for quantum-enhanced photonic sensing – *Jonas Junker*

13:00 **Lunch**

14:30 **Plenary Session 5 [PPV]** ***Auditorium***
Chair: Miguel Fernandes (CTS-ISEL)
75 Current density management in modern silicon-based solar cells – *Kaining Ding*

15:15 **Parallel Session 7 [PPV1]: Advanced Photonics for Solar Cells and Optical Power Transfer** ***Auditorium***
Chair: Steve Reynolds (University of Dundee)
59 Machine Learning-Driven Design of Photonic Crystals for Enhanced Back-Reflectors in Photovoltaic Cells – *Cosme Eustaquio Rubio Mercedes*
183 Will Carrier Mobilities and Lifetimes in SnS Thin Films Lead to Competitive Solar Cells ? – *Reinhard Schwarz*
209 Experimental Validation and Numerical Simulation of a 520 nm Optical Wireless Power Transmission System – *Elisa Casal Gómez*

16:00 **Parallel Session 7 [ENSSC1]: Photonics for Industrial Sensing and Autonomous Systems** ***Auditorium***
Chair: Micael Nascimento (i3N/UA)
212 Novel Applications of LIBS in Recycling – *Amy Bauer*
249 Optical Wireless AGV Navigation and Coordination Using Visible Light Communication – *Paula Louro*

15:15 **Parallel Session 7 [NANPHOPT2]: Optoelectronic Materials, Photodetectors, and Light–Matter Characterization** ***Maxwell Room***
Chair: José Figueiredo (University of Lisbon)
176 Influence of different wavelengths on the operation of gallium oxide-based photomemristors – *Marina Sparvoli* - (Keynote)
86 Emergent chiral phenomena in in-plane hyperbolic van der Waals $MoOCl_2$ – *Meri Hayrapetyan*
106 Optoelectronic Study and Optimization of a Hybrid Nanograting-Enhanced GaAs MSM Photodetector with Metallic Adhesion Layers – *Mohamed Khadraoui*
79 Temperature-Dependent Spectromicroscopy of Single Quantum Emitters as a Basis for Luminescence Nanothermography – *Andrei Naumov* - (Invited)

15:15 **Parallel Session 7 [LNOPT1]: Ultrafast Optical Diagnostics, Spectroscopy, and Real-Time Measurement** ***Fresnel Room***
Chair: Paulo Antunes (i3N/UA)
65 Real time processing for ultra fast Optical Coherence Tomography – *Adrian Podoleanu* - (Keynote)
158 Intensity scaling of rotational anisotropy for detection of wave-mixing processes – *Hugo Pires*
131 Generalised Thomson scattering for relativistic plasma optics – *Rafael Russo de Almeida*
150 Advances in diode-pumped metastable rare gas lasers – *Rui Wang*
154 The Impact of Ambient Gas Conditions and Delay Time on Emission Characteristics of Al Plasma Generated using Nanosecond Laser-Induced Breakdown Spectroscopy (nsLIBS) – *Atif Hussain*

16:45 Poster Session 2 and Coffee Break ***Main Hall***
OPTFSA
98 A Stability Enhanced EDF Ring Laser Interrogator for FBG Sensing: Linear Response, Low Cost Design and Practical Optimization – *Nikolaos Stathopoulos*

145 Visible Light Communication System Integrated with SUMO Simulation – *João Marques*
167 Optical Links for CubeSat Communications - Technologies and Challenges – *Erica Alves*
194 Cellular VLC-Based Vehicle Localization Integrated with SUMO Traffic Simulation – *David Almeida*
196 VLC-Enabled Multi-Agent Reinforcement Learning with Dynamic Phase Timing for Traffic Optimization – *Gonçalo Galvão*
252 Experimental Evaluation of Power-over-Fiber Topologies for IoT Sensor Deployment Over Single-Mode Fiber at 1550 nm – *Daniel Graça*
265 End-to-End Visible Light Communication Vehicular Prototype: Design and Experimental Validation – *Duarte Cruz*
142 Classical Emulation of the BB84 Quantum Key Distribution Protocol over Optical Fibers – *Rodrigo Cosme*
225 Joint Computer Vision and Multicore-Fiber Sensing for Automatic FSO Alignment – *Pedro Pereira*

18:15 SPOF General Assembly

20:00 End of the day

Friday, July 10

08:00 **Registration**

08:45 **Plenary Session 6 [MATPRCH]** ***Auditorium***
Chair: Alessandro Fantoni (CTS-ISEL)
281 The Rise of Sustainable Advanced Materials for Electronics and Energy Applications – *Rodrigo Ferrão Paiva Martins*

09:30 **Parallel Session 8 [MATPRCH1]: Advanced Optical Thin Films, Nanostructures and SERS for Sensing Applications** ***Auditorium***
Chair: Steve Reynolds (University of Dundee)
239 The impact of noble metal thin films on SERS substrates for pesticide detection – *Luminita Nastas*
246 Investigations of the properties of some organic and hybrid layers deposited on flat and patterned substrates – *Oana Raşoga*
238 Semiconductors-based Pervious Concrete for Photocatalytic Performance – *Fabíula Pereira Lessa*
51 Composite structures based on shape-controlled Ag nanoparticles embedded in c-Si as a promising SERS substrate – *Anna Ermina*
195 Coherence and superradiance from a plasma-based quasiparticle accelerator – *Bernardo Malaca* - (Invited)

09:30 **Parallel Session 8 [OPTCOM1]: Quantum Communications and Advanced LiDAR Systems** ***Maxwell Room***
Chair: Manuela Vieira (CTS-ISEL)
199 The Development of Quantum Communication Links – *Yaseera Ismail* - (Keynote)
213 First Experimental Demonstration of Chaos-Based LiDAR in the Long-Wave Infrared Exploiting Photonic Chaos – *Sara Zaminga* - (Invited)
172 Receiver Lens System Design Considerations for Wide-Angle FMCW LiDAR – *Marcus Baumgart*

09:30 **Parallel Session 8 [OPTINSTSA2]: Astronomical Instrumentation and Optical Design** ***Fresnel Room***
Chair: Manuel Abreu (University of Lisbon)
100 Advancing Optical Astronomy at ESO: Portuguese Contributions from the Institute of Astrophysics and Space Sciences – *Alexandre Pereira Cabral* - (Keynote)
125 Model-Based Systems Engineering for the Front-End of ANDES, the High-Resolution Spectrograph for the ESO Extremely Large Telescope – *Daniel Santos*
128 Towards the miniaturization of cross-dispersed echelle spectrographs: Parametric modelling and trade-off analysis of three optical designs – *Nuno M. Gonçalves*
130 Reaching the milli-arcseconds level in atmospheric dispersion correction for astronomical instruments. – *Pedro José Barreto Pereira*

10:50 **Coffee Break**

11:10 **Parallel Session 9 [MATPRCH2]: Session 2: Materials, Thermal, and Photocatalytic Applications** ***Auditorium***
Chair: Reinhard Schwarz (IST)
109 Ion Beams for Materials Processing and Characterization – *Katharina Lorenz* - (Invited)
202 Optical Methods for Self-Cleaning Assessment Across Multiple Substrates – *Orlando Lima Jr.*
170 Design and Synthesis of Magneto-Plasmonic Liposomes: Towards Dual-Mode Hyperthermia – *Fábio Alberto da Costa Lopes*
271 Laser processing of oxides for energy applications – *Nuno Ferreira* - (Invited)

11:10 **Parallel Session 9 [OPTCOM2]: Advanced Optical Communications and Photonic Networking** ***Maxwell Room***
Chair: Ana Rocha (i3N-Aveiro)
63 LUMIRing: the Largest Terrestrial Multicore Fiber Testbed Enabling Real-World SDM at Scale – *Adolfo Cartaxo* - (Keynote)

197 Photonic Enabled Multi Agent Traffic Orchestration Using Visible Light Communication for Adaptive Urban Mobility – *Manuela Vieira* - (Invited)
193 Overcoming Nonlinearities in High Power EDFAs for Coherent Ground-to-LEO Optical Links – *Ricardo Cotrim*
224 Modelling Rate-Adaptive LEO-to-Ground Coherent WDM FSO Links with Throughput and Power Optimization – *Diogo Malheiro*

11:10 **Parallel Session 9 [OPTFSA4]: Light-to-Energy Conversion in Nanostructures** ***Fresnel Room***
Chair: Vitor Oliveira (CEFEMA/ISEL)

279 Analytical Technique for the Quantification of C2H4 and CH4 – *Arthur George Tissi Batista*
218 Optimization of Hybrid Electrodes for Integrated Electrochemical Surface Plasmon Resonance (eSPR) Systems – *José Lucas Camacho Monteiro*

12:30 **Awards & Closing Ceremony**

13:00 **Lunch**

14:30 **Guided Tour to RTP Museum**

ABSTRACTS

(Preliminary Version)

ID: 22

Design of a Photonic Synopsis Multiplexer Based on Multicore Polymer Optical Fiber

Dror Malka[1,*]

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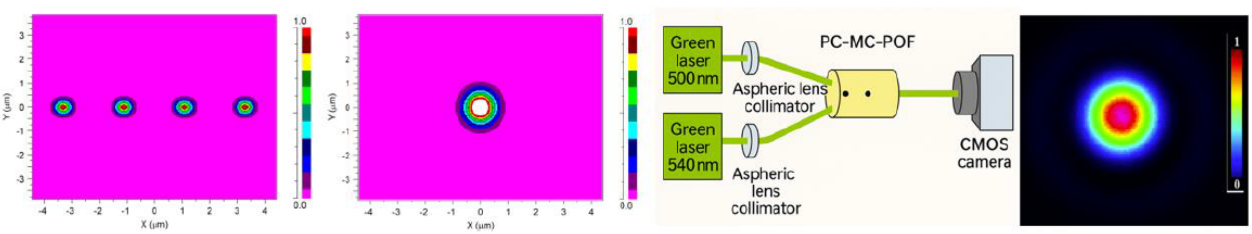
The growing demand for miniaturized photonic systems operating in the green spectral region is driving the development of integrated wavelength-division multiplexing (WDM) technologies. Conventional multiplexers rely on bulky components that introduce insertion losses and hinder compact integration. Simultaneously, the rise of neuromorphic photonic computing underscores the need for multifunctional devices capable of combining wavelength multiplexing and optical weighting within a single platform.

This work presents a four-channel green-wavelength photonic multiplexer based on multicore polymer optical fiber (MC–POF) with embedded polycarbonate (PC) cores [1-2]. The device performs passive wavelength combination through engineered coupling between adjacent cores, operating efficiently across 500–560 nm without external lenses or gratings. Simulations using the beam propagation method (BPM) confirm that a 20 mm fiber segment achieves low insertion losses (0.13–0.55 dB), uniform 20 nm spectral spacing, and thermal stability. The optimized coupling region satisfies the coupling requirements of all four wavelengths simultaneously, functioning as a photonic synapse that enables wavelength-dependent signal convergence. Experimental validation with a two-channel PC–MC–POF prototype (500 nm and 540 nm lasers) verified the predicted performance, as the measured far-field pattern closely matched simulation results. This compact architecture eliminates the need for multiple coupling sections or discrete optical components and demonstrates robust, efficient spatial multiplexing.

The proposed PC–MC–POF design offers a scalable and energy-efficient solution for green-wavelength WDM and neuromorphic photonic applications. Its controllable coupling dynamics provide a foundation for future visible-light multiplexing and all-optical neural interconnects through optimized switching-length engineering. Figure 1(a) present the simulated spatial optical field distributions at the input and output facets of the designed PC–MC–POF wavelength multiplexer. Figure 1(b) shows the experimental setup and corresponding results demonstrating the successful spatial multiplexing and combination of two green laser signals (500 nm and 540 nm) within the PC–MC–POF device.



(a) (b)

Figure - (a) Simulated results and (b) experimental validation of the PC–MC–POF multiplexer showing successful combination of two green laser signals

ID: 45

Effects of Skin Pores on Photon Propagation in Optical Brain Imaging Systems

Serhat Ilgaz Yöner[1,*], Kenan Nurettin Bilgiçer[2]

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In optical brain imaging systems, near-infrared photons emitted by light emitting diodes (LEDs) must penetrate scalp and other tissue layers to reach the brain, and even a single skin pore at the scalp-LED interface can alter optical power, yet its effect is rarely quantified. In this study, we use finite element method (FEM) simulations to examine photon propagation in a model including a single pore of 500 μm diameter and 50 μm depth within the scalp. The pore was systematically displaced along the scalp-LED boundary in 0.1 mm steps for 30 positions to investigate how its location affects light propagation, and 5000 photons at 735 nm wavelength with a 70 degree half-angle were emitted, representing specifications of typical LED sources used in optical brain imaging systems. A layered human head model consisting of scalp, skull, cerebrospinal fluid (CSF), and brain was constructed, and realistic refractive index values were assigned to each tissue layer. To assess the effect of the pore on light propagation, photon power reduction was tracked at each tissue layer interface, and pore position versus optical power graphs were plotted for all interfaces. Results show that optical power at the scalp-skull interface varied within the 89.65 to 87.77% range as the skin pore radial position changed between −1.5 and +1.5 mm, with deviations across positions. Corresponding variations were observed at deeper interfaces, with skull-CSF interface optical power ranging from 80.76 to 79.69% and CSF-brain interface optical power ranging from 68.40 to 63.73% over the same skin pore radial position range. While optical power at the scalp-skull and skull-CSF interfaces decreases as the pore approaches the LED center, an opposite trend is observed at the CSF-brain interface, where optical power increases with central pore alignment. This inversion suggests that centrally located pores disrupt near-field photon transport at superficial layers while redistributing photon trajectories toward more forward-directed paths that enhance deeper penetration. These findings highlight a source of position-dependent variability in optical brain imaging systems that can directly impact system signal-to-noise ratio (SNR) and effective depth sensitivity. Improving LED-scalp coupling, such as through controlled LED compression against the scalp, may reduce pore-induced fluctuations by effectively suppressing pore-related air gaps and improve measurement robustness at tissue layers.

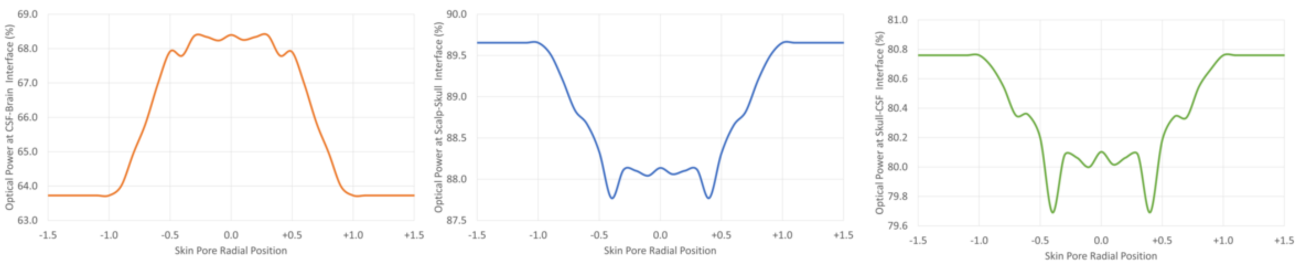

Figure - skinPoreRadialPosition vs opticalPowerAtCSF-BrainInterface, vs opticalPowerAtScalp-SkullInterface and vs opticalPowerAtSkull-CSFInterface

ID: 46

Tuning Chemical Interface Damping in Single Au–Ag Heterostructured Nanodumbbells by Adjusting the Au–Ag Atomic Ratio and the d-Band Center Position

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Plasmon damping in Au–Ag bimetallic nanoparticles is poorly understood. Herein, we synthesized dumbbell-shaped Au–Ag nanoparticles (Au-AgDBs) with increasing Ag content (from Au-AgDB1 to Au-AgDB2). Au-AgDB1 exhibited stronger damping, attributed to an interplay of the d-band center downshift, increased surface roughness, and electron transfer from Ag to Au. We further investigated chemical interface damping (CID) during the chemisorption of pyridine and 4-aminopyridine (4-AP), the latter containing an electron-donating group, on Au-AgDBs using real-time dark-field spectroscopy. Each adsorbate adopted a distinct orientation on the nanoparticle surface, governed by the nanoparticle's d-band center, which significantly affected CID. Pyridine, with overlapping molecular orbitals, enhanced CID via parallel adsorption, whereas 4-AP tended to tilt or stand upright due to steric hindrance and the resonance-active −NH2 group, as confirmed by Raman spectroscopy. This study provides new insights into how atomic composition, nanoparticle morphology, and adsorbate orientation collectively influence CID, enabling tunable plasmon damping in Au–Ag bimetallic nanoparticles.

ID: 47

Controlled Suppression of Anderson Modes in a Three-Dimensional Disordered Optical Waveguide

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Here, a robust and controllable realization of Anderson localization of light in a fully three-dimensional disordered medium is reported using a single asymmetrical optical waveguide. The waveguide is fabricated inside a fused-silica structure via a capillary-assisted process and hosts a rhodamine-doped phenol matrix containing naturally formed air inclusions and deliberately introduced silver nanoparticles. This hybrid random network enables strong multiple scattering while preserving longitudinal guidance, providing an efficient platform for controlled photon localization.

A key advance of this work is the deterministic suppression of unwanted Anderson modes through precise tuning of the disorder strength. By increasing the concentration of silver nanoparticles, multimode localization is progressively eliminated, yielding a single, spectrally stable, and strongly confined Anderson-localized cavity at the desired emission wavelength. This transition is accompanied by a marked enhancement of the cavity quality factor, indicating reduced modal competition and improved optical confinement in a disorder-driven system.

Time-resolved photoluminescence measurements reveal a pronounced modification of light–matter interaction for emitters coupled to the selected localized mode. Dye molecules resonant with the engineered Anderson cavity exhibit up to an order-of-magnitude enhancement in their radiative decay rate compared to the bulk medium, evidencing a strong Purcell-type effect arising purely from disorder-induced confinement. Importantly, this enhancement is achieved without spectral tuning or lithographically defined resonators.

Three-dimensional finite-difference time-domain simulations quantitatively support the experimental findings and confirm that the combined action of air inclusions and wavelength-scale metallic nanoparticles is essential for achieving strong localization, reduced mode volume, and controlled mode suppression. These results establish a scalable and fabrication-tolerant strategy for engineering high-performance Anderson-localized cavities in three-dimensional random media, opening new avenues for disorder-enabled photonic devices, including intelligent random lasers and robust platforms for enhanced light–matter interaction.

ID: 48

Computational Design of a TE/TM-Pass Polarization Controller on SOI Photonic Integrated Circuits

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Photonics is increasingly recognized as a key technology complementing electronics; however, it has not yet matured to fully replace electronics in industrial applications. Therefore, future system designs are integrating electronics and photonics to exploit the advantages of both in terms of performance and efficiency [1]. Silicon photonics provides an ideal platform for such integration, enabling electronic and photonic components to coexist on a single chip [2]. However, silicon birefringence leads to strong polarization-dependent device performance [3], necessitating the use of on-chip polarization controllers (PCs) [4–8]. Thus, we are proposing a compact, high-performance, and broadband silicon-based polarization controller that selectively transmits either transverse-electric (TE) or transverse-magnetic (TM) polarisation while suppressing the other, thereby minimizing performance interference.

The proposed device is numerically investigated using the FDTD method. The results demonstrate that the proposed 8x6 µm2 footprint geometry can filter out the TE mode while allowing the TM mode to pass, achieving an extinction ratio (ER) of 29 dB and an insertion loss (IL) of 0.09 dB at wavelength of 1550 nm. Additionally, the structure can suppress the TM and transmit the TE polarization with an ER of 30 dB and an IL of 0.02 dB at 1550 nm. Moreover, the device operates over a wide bandwidth from 1440 to 1670 nm (230 nm), maintaining an IL below 0.3 dB and an ER exceeding 20 dB for both TE-pass and TM-pass configurations. To the best of our knowledge, these performance metrics represent the highest reported values for a polarization controller operating over such a wide bandwidth with a compact footprint on the SOI platform.

Acknowledgements: This work is supported by the TÜBİTAK 2224 Program of Türkiye.s

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ID: 49

Development of an all optical 1 X 4 switch

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INFRACHIP is a European research platform for the sustainable development of next-generation and future semiconductor chips. This platform provides access for free state-of-the-art technologies in various facilities throughout Europe.

In this work, we report the developments of our proposal to INFRACHIP, the fabrication of a Photonic Integrated Circuit, Silicon-on-Insulator compliant and implementing an all optical 1 X 4 switch with arbitrary output selection accomplished by the Pockels effect. Follows a description of the proposed device:

- This Photonic Integrated Circuit integrates in a platform, fiber/grating couplers with the highest simulated efficiency to date (-1 dB), the shortest simulated taper waveguides to date (tens of micrometers as opposed to some millimeters), an original configuration of interacting multimode interference structures enabling the establishment of arbitrary paths linking the input to the outputs, and the Pockels effect as a means to impact the phase of the propagating mode in the waveguide. The fabricated structure will be the smallest form factor device of the kind to date, achieved through an innovative design of the structure's architecture, while implementing ultrafast switching functionality surpassing current thermoelectric, depletion or accumulation of carriers and micro-electromechanical, based systems. Since the prototype will be essentially optical, for the control of the phase is achieved only by applying an electrical field and no electrical current is involved, and all remaining structures are optically passive, this device will be highly efficient and extremely compact.

ID: 51

Composite structures based on shape-controlled Ag nanoparticles embedded in c-Si as a promising SERS substrate

Anna Ermina[1,*], Nikolay Solodovchenko[1,2], Danila Markov[1], Kristina Prigoda[1], Vladimir Bolshakov[1], Yuliya Zharova[1]

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[2] ITMO University

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In recent decades, the non-destructive method of surface-enhanced Raman scattering spectroscopy (SERS) has attracted increasing attention due to its selectivity and high sensitivity of molecules down to the "fingerprint" level. The most promising material for SERS substrates is Ag, since its plasmonic response in the visible range provides the highest electromagnetic enhancement factor (*EF*) among noble metals. Currently, the problem of producing highly sensitive, reproducible and low-cost substrates remains relevant for SERS applications [1].

This study reports an efficient, simple, and cost-effective method for synthesizing shape-controlled Ag nanoparticles (AgNPs) embedded in single-crystal silicon (c-Si) based on a galvanic displacement reaction in $AgNO_3$:HF solution, followed by high-temperature annealing in a water vapor. An embedding AgNPs mechanism into c-Si is proposed [2]. The shape of AgNPs is determined by the crystallographic orientation of c-Si. As a result, c-Si(100),(110),(111) form AgNPs in the shapes of pyramids, "boats", and truncated tetrahedrons, respectively. X-ray diffraction and energy dispersive X-ray analysis confirmed that AgNPs were not oxidized after annealing. Spectroscopic ellipsometry demonstrated that boat-shaped AgNPs, oriented along the $[1\bar{1}0]$, exhibit optical anisotropy. When the **E** of the wave relative to the AgNP axis changes from longitudinal to transverse, the localized plasmon resonance shifts by 100 nm in the range of 400-600 nm, and the magnitude of the shift is determined by the average aspect ratio of the AgNP. The functionality of structures as SERS substrates was investigated using aqueous solution of brilliant green (BG) and crystal violet (CV) triphenylmethane dyes, which are genotoxic and carcinogenic. The limit of detection of concentrations and corresponding *EFs* were 10 pM and 10^7. The detection of a mixed solution of BG and CV at a concentration of 10 nM was also investigated. The reproducibility of the SERS measurements showed that the analyte remained detectable even after the fifth application and removal [3,4].

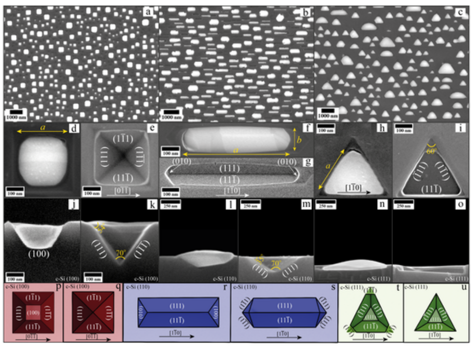

Figure - SEM image of the structures

Acknowledgements: This work was supported by the Ministry of Science and Higher Education of the Russian Federation (Project FFUG-2024-0017).

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ID: 52

Paired exceptional points and a q-BIC on a bulk Fermi arc in a single dielectric ring resonator

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Non-Hermitian photonics provides a natural framework for open dielectric resonators, where radiative leakage renders eigenfrequencies complex and enables singular degeneracies such as bound states in the continuum (BICs) [1] and exceptional points (EPs). EPs are non-Hermitian degeneracies at which both eigenvalues and eigenvectors coalesce, leading to a characteristic two-sheet Riemann-surface topology and pronounced changes in scattering response [2,3]. In multi-parameter settings, EPs typically emerge in pairs and can be connected by a bulk Fermi arc (FA) - a continuous set of parameters for which the real parts of two eigenfrequencies coincide while the imaginary parts (linewidths) remain distinct [4,5].

In this work we experimentally demonstrate a pair of EPs connected by a bulk FA in a single dielectric ring resonator, realized through two-parameter geometric tuning. We vary the inner radius R_{in} and the ring height h (with the outer radius R_{out} fixed) and study the interaction of two modes whose spectral shifts with R_{in} and h are markedly different. By tracking the complex eigenfrequencies and eigenfields across the (R_{in}, h) plane and reconstructing the associated Riemann surfaces, we identify two second-order EPs where both complex eigenvalues and eigenfunctions merge, consistent with the EP topology known in open photonic systems [2,3]. Between these EPs we experimentally find a bulk Fermi arc.

Beyond EP physics, the same two-mode interference picture predicts a quasi-BIC (q-BIC) condition, i.e., a strong suppression of radiative loss due to destructive interference of radiation channels [1,6]. Importantly, in our ring geometry the q-BIC locus intersects the bulk FA, implying that a q-BIC can be realized directly on the Fermi arc using only the experimentally accessible tuning of Rin and h. This provides a compact single-resonator route to combine EP-connected topological features with interference-based radiation suppression, offering additional control of resonance frequencies and linewidths in dielectric metastructures [1,2].

Acknowledgements: This work was supported by the Russian Science Foundation (Project 25-42-10025).

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ID: 53

Multi-parametric fiber Bragg grating sensor to monitor users of a soft hand-exoskeleton

Juan Andrés García Zapata[1,*], Marcelo Eduardo Vieira Segatto[1], Carlos A. Cifuentes[2], Camilo A. R. Diaz[1]

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Modern physical rehabilitation requires systems that ensure high patient compliance through comfort and ergonomics. Soft technologies, such as soft exoskeletons, have emerged as an alternative to rigid systems due to their high deformability and mechanical compliance. To maintain these advantages, integrated sensors must be lightweight and minimally intrusive. Fiber optic sensors, particularly Fiber Bragg Gratings (FBGs), offer an alternative solution due to their high sensitivity, multiplexing capabilities and electromagnetic immunity, which combined with their lightweight and compact size, enables them to be embedded into flexible matrices for simultaneous monitoring of kinematic and physiological data. This work focuses on developing a multi-parametric FBG-based platform, evaluating its performance against gold-standard devices, and building a dataset for machine learning-based movement recognition in rehabilitation.

The sensing network was fabricated using UV laser inscription via a phase mask technique, consisting of FBG sensors embedded in EcoFlex silicone. Strategically positioned over the carpal and radial regions, this configuration detects multi-axial wrist movements (sagittal and frontal planes) while concurrently capturing radial pulse. Validation trials were conducted with healthy subjects using a Shimmer sensor and a computer vision sensor. Participants performed multiple repetitions of fundamental wrist movements—including flexion, extension, adduction, and abduction—alongside complex gestures to ensure a diverse database.

Optical signals were analyzed using frequency-band separation: high-frequency components were utilized for physiological signal identification (radial pulse), while low-frequency components were mapped to the kinematic response of the joint. The system's performance showed high correlation with reference devices across all movement patterns. The database enabled the implementation of machine learning models to identify wrist movements, demonstrating the potential of FBG-based systems for intelligent monitoring in soft robotics devices.

This work successfully demonstrates a compact, multimodal FBG system that maintains the mechanical advantages of soft technologies. This approach offers a practical, non-intrusive solution for therapy monitoring, facilitating the future integration of intelligent feedback into hand exoskeletons for clinical use.

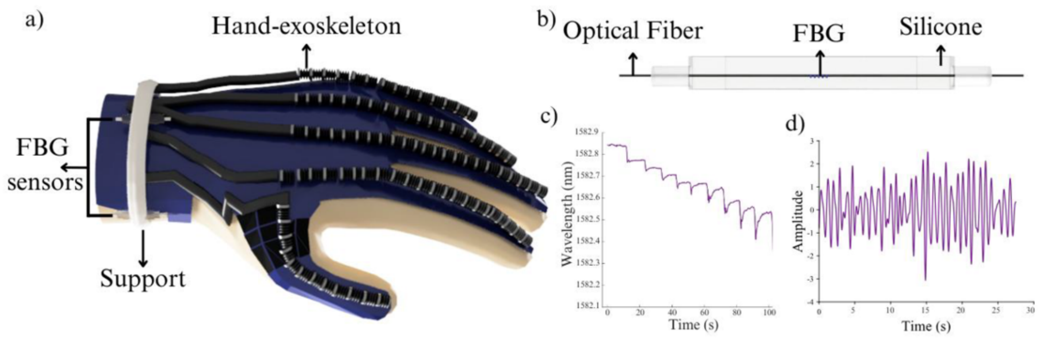

Figure - a) Exoskeleton and FBG positioning, b) Developed FBG-based sensor, c) FBG response after position changes, d) pulse signal after filtering.

ID: 55

Broadband THz Polarization Conversion with All-Silicon Metasurface

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Efficient control of the polarization of terahertz (THz) waves is essential for emerging applications in sensing, imaging, spectroscopy and high-speed wireless communications. However, various THz polarization converters based on metallic metasurfaces suffer from low transmission and low polarization conversion efficiency. In this work, it is presented a broadband terahertz polarization converter based on all-silicon metasurface that enables high-efficiency polarization transformation. The proposed convertor consists of a silicon metasurface designed with specific geometrical parameters in order to introduce a π phase shift between orthogonal field components. Full-wave electromagnetic simulations demonstrate that the engineered structure efficiently performs linear-to-orthogonal polarization conversion across the wide frequency band with high conversion ratio.

A systematic investigation on the influence of geometrical parameters indicates that the bandwidth and the polarization conversion efficiency can be calibrated by adjusting the fill factor, grating period, and dielectric thickness. The proposed all-silicon platform provides a compact, low-cost fabrication solution for polarization control for broadband THz frequencies ranges and rises amazing opportunities for the integration into next-generation THz photonic systems.

ID: 56

A Reconfigurable Free-Space Optical Fabric for Chip-to-Chip Interconnects

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We present OTenna, a CMOS-compatible, chip-scale optical phased array platform enabling dynamically reconfigurable free-space optical interconnects for next-generation computing systems. OTenna leverages liquid-crystal-steered leaky-wave photonic structures fabricated using a Damascene process to achieve compact, low-power, and continuous beam steering without conventional phase shifters. This architecture supports highly directive, two-dimensional beam scanning with sub-degree beamwidths, enabling dense spatial multiplexing and interference-resilient communication.

Unlike traditional electrical and fiber-based interconnects, which are constrained by chip perimeter I/O density and static routing topologies, OTenna scales with silicon area, allowing for a significantly higher density of communication links distributed across the chip surface. This enables a software-defined optical fabric in which hundreds of independent, high-throughput beams can be dynamically reconfigured on millisecond timescales to support evolving dataflow patterns. Such flexibility is particularly advantageous for AI and high-performance computing systems, where communication bottlenecks and rigid interconnect topologies limit scalability and efficiency.

We demonstrate the design, fabrication, and characterization of OTenna devices, including leaky-wave radiators with voltage-controlled liquid crystal tuning, two-dimensional scanning architectures, and far-field beam formation at 1550 nm with beamwidths below two degrees. Experimental results validate continuous beam steering, well-formed radiation patterns, and scalable integration of photonic components on chip, demonstrating feasibility and performance.

OTenna enables a fundamentally new paradigm for chip-to-chip and wafer-scale interconnects, supporting reconfigurable, low-latency, and high-bandwidth optical links without mechanical steering or fiber routing complexity.

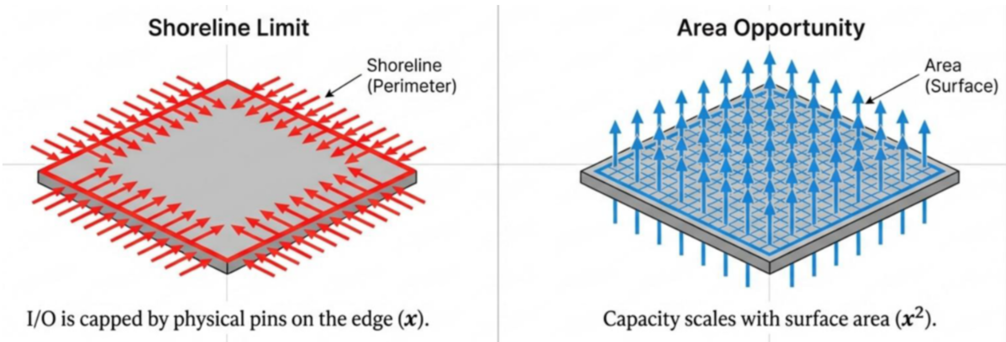

Figure - Direct connections from the CMOS chip or optical interposer as opposed to edge launched configuration

ID: 58

Hybrid Metallic-Dielectric Systems for Sensitive Optical and Biological Detection

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The integration of photonic crystals (PhCs) with plasmonic nanostructures has emerged as a powerful strategy for developing high-performance optical sensors. By merging the light-confining properties of dielectric periodic structures with the intense near-field enhancement of plasmonic modes, metal-dielectric hybrids (MDHs) offer unprecedented sensitivity and miniaturization potential. This work discusses two distinct complementary hybrid platforms.

The first part focuses on the excitation of Optical Tamm States (OTS) at the interface between a 3D inverse opal (IO) and a flat platinum substrate. Unlike conventional surface plasmons, OTS are excited under normal incidence for both TE and TM polarizations, simplifying the optical setup by eliminating bulky prism-coupling geometries. FDTD simulations and experimental data validate a resonant OTS dip within the photonic bandgap (PBG). The high porosity of the IO framework allows rapid analyte infiltration into high-field regions. Testing with volatile organic compounds (VOCs) demonstrates a sensitivity of 110 nm/RIU and recovery times as fast as 0.4 s, highlighting the platform's potential for real-time environmental monitoring.

The second part explores a hybrid platform consisting of gold nanocaps (NCs) on a 3D colloidal opal. Femtosecond transient absorption (TA) spectroscopy reveals a strong interplay between localized surface plasmon resonances (LSPR) and the PBG. A twofold enhancement of the plasmonic transient signal occurs during spectral overlap with the PBG—a phenomenon attributed to the slow-light regime and supported by transfer matrix model (TMM) predictions. As a proof-of-concept for biosensing, bacterial deposition on the surface significantly modifies the ultrafast optical response, enabling ultrafast switching of the transient signal.

In conclusion, engineering the coupling between PBG effects and plasmonic resonances provides a versatile toolbox for next-generation sensors. These hybrid architectures improve sensitivity and response times while opening new avenues for ultrafast photonic switching and label-free biological detection.

ID: 59

Machine Learning-Driven Design of Photonic Crystals for Enhanced Back-Reflectors in Photovoltaic Cells

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Photonic Crystals (1D-PCs) are essential for enhancing light harvesting in solar cells by reflecting long-wavelength photons back into the active layer. However, optimizing their multi-parametric nature (n_H , n_L, d_H , d_L , N) is computationally expensive. This study proposes a high-fidelity machine learning (ML) surrogate model to predict Photonic Bandgap (PBG) features, enabling near-instantaneous photovoltaic (PV) design.

A dataset of 5,000 Transfer Matrix Method (TMM) instances was used for validation, with 1,000 Finite Element Method (FEM) samples reserved for final testing (450 – 850 nm range). We compared four models: Linear Regression (LR), REPTree, Random Forest (RF), and Artificial Neural Networks (ANN). Correlation analysis identified (n_H as the primary driver for bandwidth expansion (r = 0.60), while n_L showed a significant negative correlation (r = −0.47).

The comparative analysis revealed a clear progression in predictive accuracy. While LR was limited by optical nonlinearity (R^2 = 0.8020), the ANN achieved near-perfect convergence with an R^2 of 0.9982 on the FEM test set and an MAE of 2.72 nm. The minimal performance drop between TMM and FEM stages (less than 1%) confirms that the models learned the underlying physics rather than merely memorizing data. These findings validate the ANN as a robust digital model for 1D-PC for enhanced back-reflectors, providing a foundation for future autonomous inverse design and light-trapping optimization in high-efficiency solar cells.

Acknowledgements: This work was supported by FUNDECT (Process No. 83/049.252/2024).

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ID: 60

Emerging Trends in Optical Metrology for Optical Communication Systems.

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Optical fibre communication systems continue to face increasingly demanding challenges in the pursuit of higher transmission rates, more advanced multiplexing schemes, longer transmission distances without signal regeneration, the implementation of more effective security mechanisms, the integration of sensing functionalities, and, more recently, the deployment of optical communication solutions for low Earth orbit and deep-space applications.

Within this context, new challenges also emerge in the field of metrology, particularly in the accurate measurement of physical quantities such as time, frequency, power, and linearity under increasingly extreme operating conditions.

ID: 61

Decoupling Imaging Geometry from Optics Using Digital Holography

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Lens-based imaging approaches inherently constrain imaging geometry, system footprint, and achievable observation perspectives, often requiring complex optical designs to balance resolution, field of view and aberration control. As optical inspection increasingly moves toward compact, flexible, and computationally driven instrumentation, alternative paradigms for image formation are becoming desirable.

Digital holography provides access to the full complex amplitude of an optical wave field, enabling numerical propagation by solving the Rayleigh-Sommerfeld diffraction integral [1]. It can therefore be employed to decouple the image formation process from physical lens systems [2]. Lensless coherent imaging represents a particularly attractive concept, allowing imaging geometries to be defined during reconstruction rather than fixed by optical components. Recent advances in high-resolution image sensors and computational wavefront processing have significantly expanded the accessible space–bandwidth product, opening opportunities for imaging configurations that are difficult or even impossible to achieve using conventional optics.

Here we explore how lensless digital holography enables a range of unconventional imaging concepts for optical metrology. We demonstrate compact lensless microscopy combining sub-micrometre resolution with minimal system footprint and variable focus [3], as well as lensless white-light interferometry suitable for industrial surface inspection [4]. Beyond miniaturization, holographic reconstruction enables generalized perspective imaging, in which hypercentric, telecentric, or entocentric viewpoints can be rendered from a single hologram [5], and sideways imaging which provides aberration-free observation under strongly oblique viewing angles [6]. These results illustrate a shift from optics-defined imaging systems toward computationally defined measurement architectures, which expand the boundaries of optical imaging and inspection.

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ID: 62

A Photonic Journey: From Systems to Devices

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Advanced photonic systems demand tight co-design across system architectures, photonic integrated circuits (PICs), and underlying device physics. However, existing design flows remain fragmented, limiting the ability to accurately propagate device-level effects to higher levels of abstraction This presentation introduces an end-to-end, simulation-driven workflow that seamlessly connects electro-optical (EOE) system modelling with hierarchical PIC design, with a particular focus on rigorous device-level simulation. At the core of this approach are physics-based device solvers for both passive and active components—such as waveguides, couplers, resonators, modulators, detectors, and meta-surface structures—enabling accurate analysis of propagation loss, dispersion, nonlinearity, and manufacturability effects. Through representative application examples including optical transceivers, wavelength-division multiplexing (WDM) components, and meta-optics, we demonstrate how device-level simulation and optimization feed compact models to the circuit and system levels in a tightly integrated workflow. By combining device simulation with open, interoperable workflows, this approach reduces design iterations, improves correlation between simulation and fabrication, and accelerates development from early system exploration to fabrication-ready photonic devices.

ID: 63

LUMIRing: the Largest Terrestrial Multicore Fiber Testbed Enabling Real-World SDM at Scale

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We present LUMIRing, the largest terrestrial multicore fiber (MCF) testbed, deployed in the demanding environment of the Lisbon underground. The infrastructure integrates five MCF types and supports long-distance emulation, enabling real-world evaluation of space division multiplexing systems and flexible network topologies. We report recent experimental measurements, highlighting key transmission and physical-layer characteristics of the testbed.

ID: 65

Real time processing for ultra fast Optical Coherence Tomography

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I will present the bottleneck in digital signal processing raised by the combination of an interferometer with a multi MHz tuning rate laser. Traditionally, in order to produce a volumetric image, a Fourier Transform (FT) is applied to the electrical signal delivered by reading the channeled spectrum at the interferometer output. We proposed an alternative signal processing method that does not rely on a FT and changes the main result of signal processing, from information along the axial coordinate to that along the transversal coordinate. This method, termed as Leader Follower (LF) [1] as well as its several facets, will be presented, such as Complex Leader Follower (CLF) [2] and Downconversion Leader Follower (DLF) [3]. DLF can serve delivery of en-face OCT images in principle at any high sweeping rates, of MHz or tens of MHz. DLF uses digitizers at a much reduced sampling rate, comparable with the tuning frequency, which is a few hundreds or a few thousands less than the frequency of the photodetected signal. Novel fast methods for tuning applicable to OCT will also be presented. In addition, how DLF can be employed to present images in real time using fast novel bidirectional tuning lasers [4].

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ID: 66

Photoacoustic Spectroscopy for Ambient Aerosols Characterization

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Photoacoustic spectroscopy (PAS) is a highly sensitive, filter-free, in-situ technique for directly characterizing light-absorbing ambient aerosols. These aerosols, including black carbon (BC), brown carbon (BrC), and other combustion- and natural-source particulates, strongly influence climate through absorption of solar radiation, positive radiative forcing, and air-quality degradation. Unlike conventional filter-based methods, such as aethalometers, which suffer from particle loading artifacts, scattering biases, and matrix effects, PAS measures absorption of suspended particles in real time without such interferences.

The technique is based on the photoacoustic effect: modulated laser light (typically at multiple wavelengths) is absorbed by aerosol particles, converting light energy into heat. This periodic heating generates acoustic waves in the surrounding air, which are detected by a sensitive microphone. The signal amplitude is directly proportional to the aerosol absorption coefficient. Multi-wavelength PAS systems enable calculation of the absorption Ångström exponent (AAE), which helps differentiate BC (AAE $\approx$ 1) from BrC and other organic aerosols (higher AAE).

A standard PAS instrument features modulated lasers, a resonant acoustic cell to amplify the signal, a microphone detector, and lock-in amplification for noise reduction. Modern compact designs integrate multiple wavelengths into a single resonator, achieving detection limits below 0.1 Mm−1.

PAS is widely applied in urban, remote, and aircraft campaigns for real-time BC mass monitoring, absorption enhancement studies (coating lensing effect), and source apportionment. When coupled with nephelometers, it provides the single-scattering albedo (SSA). Its key advantages are direct, artifact-free measurement, high time resolution, and strong field robustness, though it remains sensitive to acoustic noise, laser-induced heating of volatile particles, and requires careful calibration.

The Laser and Aerosol Research Laboratory (LARLab) has been a pioneer and at the forefront in developing advanced instruments for characterizing ambient aerosols as well as those generated from exhaust engines. LARLab introduced real-time source apportionment for the first time, and a novel laser-ablation method to generate aerosols that closely mimic real-world combustion particles, significantly advancing aerosol research and instrument validation.

ID: 67

From Ultralow-Concentration Biosensing to Vibrational Fingerprint Selectivity with Bound States in the Continuum Metasurfaces

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Bound states in the continuum (BICs) sustained by metasurfaces are emerging as powerful nanophotonic platforms for biosensing and spectroscopy, owing to their ultrahigh-Q resonances and strong electromagnetic-field confinement. Although embedded in the radiation continuum, these modes remain effectively decoupled from radiative losses, enabling sharp spectral features and enhanced light–matter interaction. These properties make BIC-based systems highly attractive for label-free biosensing, real-time monitoring of biomolecular interactions, and surface-enhanced Raman spectroscopy (SERS).

Here we present recent advances in BIC-enabled photonic platforms for integrated biochemical sensing. Our work focuses on all-dielectric metasurfaces engineered to sustain high-Q resonances while remaining compatible with scalable fabrication and microfluidic integration. By functionalizing large-area transparent devices with selective biorecognition elements, including proteins, aptamers, and molecularly imprinted polymers, we demonstrate selective detection of analytes down to the femtomolar range. These systems enable direct, label-free, real-time observation of molecular recognition, providing access to interaction dynamics and binding kinetics.

A major research direction concerns hybrid dielectric–plasmonic architectures, in which the narrow spectral response of BIC-assisted dielectric resonances is combined with the intense near-field localization of metallic nanostructures, such as gold nanoparticles. By tailoring the coupling between photonic and plasmonic modes, these platforms enable selective Raman enhancement while preserving sensitivity to refractive-index changes associated with biomolecular binding. This dual functionality allows simultaneous acquisition of label-free sensing signals and spectroscopic molecular fingerprints on a single chip.

Finally, we discuss hollow BIC configurations for enhanced optical sensing. Silicon slotted metasurfaces with circular and rectangular slot geometries are designed to confine the optical field inside low-index air regions through Mie-type mechanisms. Unlike conventional dielectric nanostructures, where the field is mainly concentrated in the high-index material, these hollow architectures maximize interaction between the optical mode and the surrounding analyte, improving sensitivity.

These results highlight the potential of BIC-enabled photonic architectures for next-generation biosensing and bioanalytics.

ID: 68

Light Sheet Fluorescence Microscopy for Biophotonics

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Light Sheet Fluorescence Microscopy (LSFM) is a powerful imaging technique that, despite being conceptually introduced over a century ago, has seen widespread adoption in biology over the last decade. LSFM enables long-term, low phototoxic imaging of biological specimens, combining a large field of view with single-cell resolution, optical sectioning, and fast acquisition rates. This approach is well suited for studying a wide range of living samples, from small and optically transparent organisms to large, optically cleared tissues and organs. In LSFM, fluorescence is excited using a thin laser light sheet restricted to a single plane, while the emitted signal is collected orthogonally by a detection objective and a camera. By limiting illumination to the imaged plane, the technique provides intrinsic optical sectioning without the need for pinholes or high laser powers, thereby reducing photodamage and photobleaching. Three-dimensional datasets are obtained by translating the specimen through the light sheet and acquiring a stack of two-dimensional images at different depths. Owing to these characteristics, LSFM has become a valuable tool for in vivo studies in developmental biology and for investigating fast biological processes. In this presentation, selected applications of LSFM will be presented, including imaging of calcium dynamics in *Arabidopsis thaliana* roots, functional imaging in the zebrafish brain, and live imaging of *Hydra vulgaris.*

ID: 69

Liquid Solitons in Photonic and Quantum Systems

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We present new families of two dimensional eigenstates of a certain class of Schrödinger equations with nonlinear potential functions that depend on the probability density in such a way that for low amplitudes, attractive interactions are dominant, whereas for higher concentrations repulsive forces prevale. We show that top-flat solutions that appear in those systems, arise naturally if a small gain term is added to the evolution equation. This behavior, together with the self-cleaning properties of these liquid solitons, yield self-trapped profiles in a very fast and simple way. We show examples with different types of systems, both in photonics and quantum matter, and solutions including light beams carrying angular momentum, among others.

The mathematical model to obtain top-flat *liquid solitons* basically consists of a generalized nonlinear Schrödinger equation (NLSE) featuring nonlinear terms of opposite signs, as for instance in the well-known cubic-quintic case, and add either linear or nonlinear gain. The result would be an equation of the form:

$$i, \partial_z \psi + \frac{1}{2}\nabla_\perp^2 \psi + |\psi|^2\psi - |\psi|^4\psi = i\gamma|\psi|^2\psi, \tag{1}$$

where the nonlinear gain term $i\gamma|\psi|^2\psi$ acts by "injecting" particles into the regions of highest intensity. In practice, this implies that the high-intensity core receives a stronger energy contribution than the periphery. This effect reinforces the homogeneity of the plateau and the expansion of the central domain with its characteristic amplitude, continuously generating the entire family of possible eigenstates. From a dynamical point of view, the nonlinear gain does not directly set the intensity value of the plateau—which is determined by the cubic-quintic competition—but rather controls the spatial extent of the soliton and the speed at which the flat-top structure forms during evolution. The result is a localized structure with a flat interior and well-defined edges, analogous to a droplet with practically constant density, which justifies the name *liquid soliton*.

Another interesting example is the case of symmetric two-dimensional quantum droplets that display a nonlinear potential of the form $-|\psi|^2 ln(|\psi|^2)$, which yields a very similar physical response to the above cubic-quintic model, that is compared both numerically and analitically.

ID: 71

High-energy meta-optics for structured laser-matter interactions

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Meta-optics offer a compelling route to bring the full toolbox of structured light into the high-energy laser domain. In this talk, I will discuss how metasurfaces and related flat-optics platforms can enable compact, robust, and multifunctional control of phase, polarization, and, increasingly, spatiotemporal structure in regimes relevant to laser-matter interaction. The central challenge is that most conventional metasurfaces are not designed to withstand the optical fluences required in ultrafast high-field experiments. I will therefore focus on recent progress in full-silica low-index meta-optics, where the combination of monolithic glass platforms, broadband transparency, and high laser-damage resistance opens a realistic path toward structured beams at extreme intensities.

I will highlight our recent demonstrations of high-aspect-ratio, ultra-tall silica nanopillars that recover full phase and polarization control even in a low-index material, enabling efficient generation of structured light under conditions compatible with intense femtosecond lasers. These developments connect directly to a broader program in structured laser-matter interactions, where tailored beams such as vortex and space-time wave packets can impact applications including laser wakefield acceleration and nonlinear frequency conversion as a new control knob for high-field science.

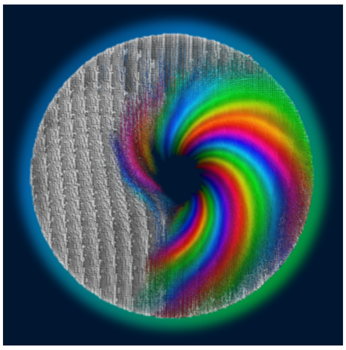

Figure - Metasurface conceptual image

ID: 72

Quantum Photonic Chips for Quantum Entanglement Distribution Networks

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Quantum entanglement serves as the fundamental resource for quantum information technology, and quantum entanglement distribution networks are crucial for enabling multi-user quantum information applications. Integrating the node functions of the networks on quantum photonic chips is an important way to extend the scales and functions of quantum entanglement distribution networks. Silicon photonic chips have the capability to integrate the generation and manipulation of photonic quantum states at telecom bands, making them suitable for these applications. Recently, the platform of thin film Lithium Niobate (TFLN) chips developed rapidly, showing the significant capacity on achieving high-speed modulation and low loss delay lines. In this talk, I will introduce our latest works on applying quantum photonic chips to quantum entanglement distribution networks: 1) A scheme of quantum entanglement distribution networks enabling complex network topologies is proposed and experimentally demonstrated, achieved through pump management of quantum light sources based on spontaneous four-wave mixing in silicon waveguides. 2) Long-distance quantum teleportation between silicon photonic chips is achieved, with an optical fiber transmission distance of 12 km. 3) A scheme of on-chip time-bin to path encoding converter on TFLN chips is proposed and demonstrated, which could be used as an interface between the on-chip photonic quantum information processing and the quantum information transmission between chips through optical fibers.

ID: 73

Towards the quantum noise limit in mid-infrared Quantum and Interband Cascade Lasers

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Extending quantum technologies to the mid and far infrared spectral range is of utmost interest especially because molecular rovibrational transitions fall in this wide spectral range. However, generation of nonclassical radiation requires tight control and shaping of technical and intrinsic laser noise. In our group, we pioneered investigation and understanding of the physical mechanisms underpinning phase and frequency noise in QCLs [1,2] and ICLs [3], observing the intrinsic linewidth in these lasers. More recently, we focused the attention on intensity noise in these two mid-IR emitting lasers, trying to single out nonclassical photon emission [4-7]. To this purpose, we developed custom-made electronics able to feed the lasers with sub-shot-noise current (down to about 10 dB below the shot noise limit). Moreover, we theoretically and experimentally investigated the amplitude and frequency noise of QCLs and ICLs, also in external-cavity configuration [8].

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ID: 74

Characterizing Structured Polarizing Elements through Matrix-Based Fourier Optics

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This presentation will show simple experiments that generalize the classical Fourier optics approach of scalar diffraction to a vectorial or polarization diffractive optical elements. A Fourier transform Jones (FTJ) matrix approach will be presented. In combination with the beam coherence polarization (BCP) matrix, the method is extended to include illumination unpolarized light.

This approach will be shown applied to handle simple meaningful examples including patterned polarizers [1] are patterned retarders [2]. It will be shown the polarization and coherence structure pattern created in the far field by simple diffractive apertures like polarizing rectangular apertures or polarization diffraction gratings. Results will compare situations illuminating the diffractive apertures with fully polarized light or with unpolarized light.

Experimental evidence will be presented exploiting the properties of liquid-crystal spatial light modulators.

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ID: 75

Current density management in modern silicon-based solar cells

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Current density management has become a central challenge in modern high-efficiency silicon-based solar cells. A general introduction to modern PV and how photonics/light management research are key elements in advancement in these solar cells will be given. This contribution discusses optical loss mechanisms at the cell level, with a focus on parasitic front-side absorption in TOPCon and silicon heterojunction (SHJ) devices. For SHJ, special attention is given to the influence of nanocrystalline silicon oxide (nc-SiOx) and nanocrystalline silicon carbide (nc-SiC). In addition, the presentation addresses current-matching constraints in perovskite-silicon tandem cells, where the photocurrent of the silicon bottom cell is strongly affected by long-wavelength light management. A key aspect is the control of rear reflectance at the back of the bottom cell to enhance the optical path length and improve infrared response. The talk focuses on device-level optical and electrical trade-offs relevant to current generation and balancing, while module-level optics are intentionally excluded.

ID: 76

Holographic endoscopy: challenging the limits of conventional imaging

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Multimode fibres are not conventional imaging devices. Coherent light coupled into a multimode fibre is scrambled into a complex speckle pattern at its output. Rather than representing a fundamental limitation, this complexity can be exploited. By combining wavefront shaping with digital holography, multimode fibres can be transformed into powerful imaging systems, offering a high level of control over their output field [1].

Holographic multimode fibre endoscopes are rapidly emerging as powerful tools for minimally invasive deep brain imaging, enabling the probing of neuronal activity and connectivity in regions that remain inaccessible to conventional optical systems [2].

However, the community has largely overlooked the potential of using multimode fibres to image objects or samples located beyond the calibrated plane.

In this talk, I will first introduce the principles of light shaping through multimode fibres and show how they can be converted into imaging systems [1,3,4]. I will then highlight key applications in deep brain imaging [2], including the implementation of advanced microscopy techniques, such as super-resolution imaging [5,6].

Finally, I will challenge the common perception that multimode fibre imaging is restricted to a small volume around a calibrated plane, with only limited refocusing extent. I will demonstrate that the potential of this approach extends far beyond conventional microscopy: with a single calibration, a multimode fibre can image over an effectively unlimited range of working distances - from macroscopic objects in the far field to structures located near the fibre facet - all in the same imaging session.

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ID: 78

Three-dimensional label-free imaging of rapid biological cell dynamics via interferometric multiplexing

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Label-free optical microscopy employs nondestructive approaches to visualize biomedical samples. It utilizes endogenous intrinsic signals rather than specific exogenous markers or genetic modifications, which may perturb the natural biological processes, dynamics, and responses of live cells. A major challenge in optical microscopy of live cells is achieving affordable, label-free, three-dimensional (3D), and fully quantitative measurements that provide high-resolution morphological and content-based mapping of dynamic cell populations at the single-cell level. The extent of spatial and quantitative molecular information that can be extracted by label-free techniques, encompassing not only structural but also content-based data, represents a significant advantage over conventional imaging methods. Off-axis interferometric multiplexing enables the simultaneous capture of several complex wavefronts, each encoded with a distinct interference fringe orientation, using a single camera exposure. This capability gives rise to numerous applications, particularly for imaging dynamic biomedical samples. These include field-of-view multiplexing, depth-of-field multiplexing, angular perspective multiplexing for tomographic phase microscopy in 3D refractive index imaging, multi-wavelength multiplexing for phase unwrapping or spectroscopy, super-resolution interferometric imaging with a synthetic aperture, imaging of ultrafast events, measurement of the Jones matrix and sample birefringence, and the simultaneous acquisition of multiple fluorescence microscopy channels alongside quantitative phase profiles. Each of these techniques opens new opportunities for applying wide-field interferometry to efficiently measure complex biological dynamics. One application that can particularly benefit from interferometric multiplexing is label-free imaging flow cytometry, which holds significant potential for medical diagnosis due to its ability to analyze large numbers of biological cells in flow from samples obtained from body fluids. I will present our recent results in 3D label-free interferometric imaging flow cytometry for liquid biopsies, featuring real-time cell analysis and sorting capabilities for cancer monitoring, blood analysis, and sperm selection for in vitro fertilization.

ID: 79

Temperature-Dependent Spectromicroscopy of Single Quantum Emitters as a Basis for Luminescence Nanothermography

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Results of the development of luminescence nanothermometry based on single quantum emitters are presented. In temperature-dependent luminescence nanoscopy experiments on single molecules in solid matrices, we demonstrate the key role of impurity-induced resonant modes in zero-phonon line broadening. [1] Thermal broadening and shift of exciton spectra of colloidal quantum dots determined by local phonons. [2] Particular attention is paid to the discovery of enigmatic LX color centers in diamonds synthesized by the HPHT method. [3] These centers exhibit unique bright narrow-band luminescence that retains high temperature sensitivity up to room temperature. The achieved temperature measurement accuracy is 0.1 °C with an exposure time of only 100 ms, opening prospects for ultra-precise measurements in biomedicine and nanophotonics. The multimodal fluorescence nanoscopy being developed enables the mapping of temperature fields with subdiffraction spatial resolution. The report emphasizes that further progress in this direction is largely determined by the implementation of innovative hybrid methods for nanostructure synthesis. Among the key approaches is the combination of DNA origami technique [4] with electron beam nanolithography [5], which ensures precise positioning of single emitters, control over their photophysical properties, and the creation of active substrates for giant Raman scattering. The integration of advanced synthetic methods with high-sensitivity spectroscopy of single quantum objects forms the foundation for a new generation of sensing and imaging technologies. [6]

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ID: 80

Application of Photonics-Based Spectroscopy and Machine Learning in Rare Earth Element Prospectivity Modelling

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The increasing strategic importance of rare earth elements (REEs) in energy transition technologies and high-performance electronics necessitates the development of rapid, in-situ, and high-resolution exploration techniques. We report a machine learning–driven hybrid analytical framework integrating Raman Spectroscopy (RS) and Laser-Induced Breakdown Spectroscopy (LIBS) for field-deployable quantitative REE detection and mineralogical discrimination in radiothermic carbonatitic systems. Raman spectroscopy enables phase-specific identification through vibrational mode characterization, while LIBS provides elemental composition via plasma emission spectra.However, both techniques generate high-dimensional, noise-prone spectral datasets characterized by overlapping peaks and matrix effects. To address these challenges, this work employs a comprehensive preprocessing pipeline including baseline correction, denoising, normalization, and wavelength calibration, followed by feature extraction using principal component analysis (PCA) and nonlinear manifold learning techniques. Multivariate calibration is performed using partial least squares regression (PLSR), support vector regression (SVR), and gradient boosting regression. Convolutional neural networks (CNNs) are further implemented to exploit local spectral patterns for automated feature learning directly from raw spectra. Supervised learning models, including support vector machines (SVM), random forests (RF), and gradient boosting algorithms, are trained to classify REE-bearing mineral phases and predict elemental concentrations across diverse field matrices.Preliminary results demonstrate promising model performance, with classification accuracies exceeding 88–93% across major REE-bearing phases and regression models achieving coefficients of determination (R2) above 0.85 for key elements such as La, Ce, and Nd. The CNN-based models show improved robustness to spectral noise and matrix effects relative to traditional methods, reducing prediction error (RMSE) by up to 20%. Cross-validation, confusion matrices, and regression error metrics confirm the reliability and generalizability of the models across heterogeneous datasets.This research demonstrates enhanced sensitivity and specificity in REE detection compared to conventional geochemical assays, alongside significant reductions in analysis time and sample preparation requirements.

ID: 81

Reliability of opto-electronic components in space

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Opto-electronic components are key devices for space missions.

That regards in particular the power supply of satellites, space stations and in future also settlements on the moon and in a still longer future also on Mars. Therefore next generation solar cells are an increasingly important field. New materials emerge and it will be shown that particularly for large area installations in space, the state-of-the-art commercial solar cells will be rivaled by new solutions. In particular Perovskite single junction, but even more all-Perovskite based multi-junction solar cell are promising solutions due to their high radiation tolerance and also due to their good high temperature performance. Latest developments regarding their reliability and also regarding their possible manufacturability in space will be presented.

Reliability in space is endangered by extreme temperature cycling, energetic particle bombardment and for near-earth missions also by space debris bombardment.

Another class of important optoelectronic devices in space are optical emitters and sensors.

To name a strongly developing field is the realization of a quantum internet. A worldwide quantum internet involves necessarily satellites, because quantum information cannot be transported over very-long purely terrestrial channels, like optical fibers.

In particular our investigations regarding two particular component types will be shown.

Firstly the reliability under proton irradiation of vertical cavity surface emitting lasers (VCSELs) will be discussed. These type of lasers are more and more replacing conventional edge-emitting devices and allow for example a miniaturization of atomic clocks, a key electronic system for navigation systems.

Last but not least, the stability of a particular detector component – SiC based photo-detectors – under space conditions will be discussed.

Silicon carbide has the fame to be radiation hard compared to Silicon and that is surely true for power electronic components, as for example Schottky diodes and MOSFETs. The question is more complicated for applications, where minority carrier lifetime play an important role and that is the case for photodiodes. It will be shown, that radiation induced current monitoring during irradiation test can give important and easy to obtain information also regarding the opto-electronic property variations of the SiC based photo-receivers under energetic particle bombardment.

ID: 86

Emergent chiral phenomena in in-plane hyperbolic van der Waals MoOCl2

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Van der Waals (vdW) crystals offer unique opportunities for nanophotonic applications owing to their intrinsic anisotropy. While many vdW materials exhibit uniaxial behavior from weak out-of-plane interactions, some families display pronounced in-plane biaxial anisotropy. Among them, vdW oxychlorides are particularly intriguing, as their in-plane crystallographic axes can exhibit metallic or dielectric responses at optical frequencies[1,2,3] enabling unconventional optical responses and strongly confined electromagnetic mode.

In this work [4], we report the dynamic dielectric permittivity tensor of vdW MoOCl2 across the ultraviolet (UV)–visible (Vis) spectral range, extending into the near-infrared. By resolving anisotropic optical constants, we confirm hyperbolic behavior with an onset at $\lambda \approx 509$ nm and identify an additional hyperbolic window in the UV. The coexistence of multiple hyperbolic regimes enables unusual light–matter interactions, including highly confined polaritonic modes and enhanced nanoscale optical responses.

Furthermore, we propose nanoscale handedness-preserved circular polarizers based on twisted helical vdW MoOCl2 heterostructures. The combination of strong in-plane anisotropy and twist-induced symmetry breaking enables robust chiral optical responses. These results establish vdW MoOCl2 as a promising platform for hyperbolic and chiral nanophotonics, opening routes toward polarization-selective devices and engineered light-matter interactions in low-symmetry layered materials.

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ID: 90

Photonic Plasmonic Paper Platform for Multimodal Optical Sensing

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Optics based sensing technologies are central to the evolution of point of care diagnostics and personalized health monitoring. In this context, plasmonic nanostructures have emerged as key photonic elements due to their strong light–matter interactions and tunable resonances in the visible and near infrared spectral regions. Here, we present a plasmonic paper platform engineered by integrating gold nanoflowers (AuNFs) into the three-dimensional fibrous network of cellulose, creating a large area optical substrate with high nanoparticle density and uniform distribution. This hybrid material functions as a photonic transducer enabling two complementary sensing modalities: localized surface plasmon resonance (LSPR) detection and colorimetric readout.

LSPR based sensing is demonstrated through the detection of a model analyte, mercaptoundecanoic acid, highlighting the substrate's capability for refractive index sensitive optical transduction. In parallel, the chromatic response of the plasmonic paper is analyzed via RGB based optical simulations and experimentally validated using a Cyber Physical System (CPS) prototype designed for advanced colorimetric molecular detection. Functionalization of AuNFs with IL6 antibodies further illustrates the platform's ability to generate distinct optical signatures upon biomolecular interaction.

Overall, this work introduces a low cost, flexible, photonic substrate that bridges plasmonics, optical sensing, and CPS enabled readout, offering a promising route toward scalable, portable, and multimodal optical biosensing technologies.

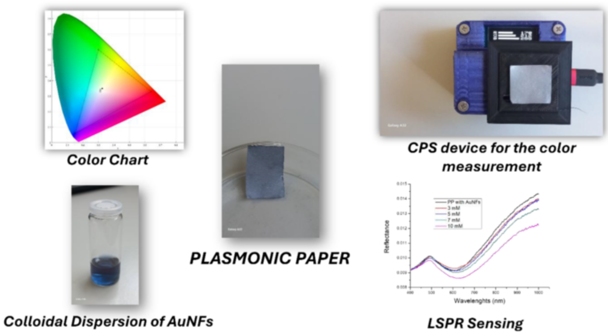

Figure -

ID: 93

PoET: a spatially resolved Sun in a high-resolution spectrograph

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Among the billions of galaxies and stars in the universe, Earth remains the only known host of life. Although nearly 6000 exoplanets have been identified to date, an Earth analogue, a planet of comparable size orbiting a solar-type star at a similar distance, has yet to be confirmed. This limitation arises primarily from stellar "noise," the intrinsic variability of stars. It has been demonstrated that the combined effects of convective plasma motions, magnetic activity, dark spots, and photospheric granulation introduce complex spectroscopic signatures that can obscure or mimic planetary signals. Most studies focus on solar-type stars and rely on accurate, regular, full-disk radial-velocity (RV) observations derived from integrated spectra. Since the surfaces of these stars cannot be resolved, all diagnostics of surface inhomogeneities must be inferred indirectly. To discover Earth twins or other long-period terrestrial planets orbiting solar-type stars, ground-based RV precision must improve by roughly an order of magnitude to reach the □10 cm s−1 regime. Our Sun—the only star that can be resolved at high spatial and temporal resolution—thus provides a unique benchmark for developing realistic models of stellar noise, motivating the design of new solar-referencing instruments.

To address this challenge, we developed the Paranal solar Espresso Telescope (PoET), an instrument based on a 600 mm solar telescope designed to characterise stellar noise using the Sun as a reference. PoET's optical Front End couples sunlight into ESPRESSO (the Echelle SPectrograph for Rocky Exoplanets and Stable Spectroscopic Observations), one of the most stable and highest-resolution spectrographs currently available. This configuration enables simultaneous disk-integrated "Sun-as-a-star" spectra and spatially resolved observations over areas ranging from 1 to 55 arcseconds, at a spectral resolution of R $\approx$ 200 000.

By combining solar observations at multiple spatial scales with ESPRESSO's precision, PoET provides a unique framework to study the spectral impact of surface inhomogeneities and magnetic activity on radial velocity measurements.

This work presents the optical and mechanical design of PoET, its integration and commissioning at the European Southern Observatory's Paranal site in Chile, and initial performance results demonstrating its capability to support future exoplanet detection and stellar noise mitigation strategies.

ID: 94

Single-Photon Detectors for Satellite-Earth QKD Links

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Cryptography is a vital part of modern society, allowing for secure transfers of information, without risk of it falling into the wrong hands. However, progress towards developing a quantum computer threatens to break part of modern cryptography, since many of its protocols are based on encoding information through very difficult mathematical problems. These would take an unreasonable amount of time to break, even with the full computational power of the best modern computers. Quantum computers, however, are theoretically capable of computational power orders of magnitude greater than those [1]. One of the best ways to counter this threat is to use Quantum Key Distribution. QKD uses the laws of quantum mechanics to create theoretically unbreakable protocols, e.g. the most popular one: BB84. In this protocol, bit values are transferred by transmitting, through a quantum channel, single-photons that are randomly polarized in one of two bases [2]. The receiver measures each photon on a random basis and registers the bit values. After the transfer, they use a classical channel for post-processing, and the secret key is created [3,4]. In this work, we address a major problem of these protocols, i.e., the usage of single-photons that severely limits the maximum distance the signal can cover, as the photons can be lost in the quantum channel, and the protocol's quantum nature prohibits the use of amplifiers. To overcome this, and for QKD to have global coverage, a satellite-earth link approach is mandatory. This approach reduces the attenuating quantum channel to just a few kilometers of atmosphere, with the rest of the optical path being vacuum, which has practically zero attenuation. Even so, this type of link still suffers from high losses, which is why the single-photon detector (SPD), a key component of the QKD receiver, needs to have high efficiency values [3,4]. We have analysed different SPDs (ID210, Aurea, ID230) to establish a method for characterizing their efficiency and dark count rate [5]. We also give particular attention to superconducting nanowire SPDs, top-of-the-line detectors with efficiencies of up to 95%. The remaining QKD receiver's components have also been thoroughly characterized, envisioning SKR estimations.

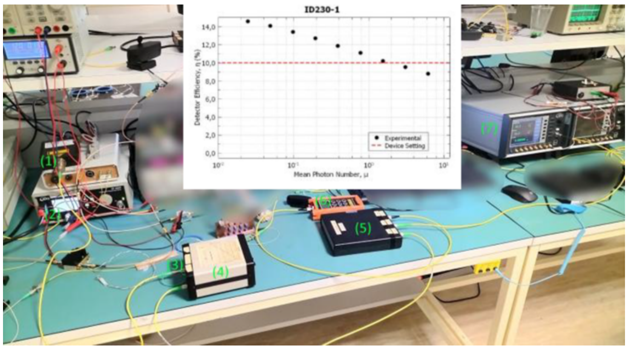

Figure - Experimental setup to characterize the efficiency and dark count rate of the single-photon detectors. The inset shows the measured efficiency vs mean photon number for the ID230 SPD.

ID: 95

A Gigahertz Thin-Film Lithium Niobate Phase-SLM Architecture for True Matrix–Matrix Multiplication in Photonic AI Accelerators

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Matrix–matrix multiplication (MMM) is the dominant computational primitive in modern deep-learning workloads, and its electronic implementation is increasingly bounded by the energy and interconnect limits of CMOS. Existing photonic accelerators largely perform only matrix–vector multiplication (MVM) or operate at limited scale ($N \leq 256$ for MZI meshes, $N \leq 100$ for WDM microring arrays). We present a free-space photonic MMM architecture that combines two thin-film lithium niobate (TFLN) phase-only spatial light modulators (SLMs) in a 4-f Fourier relay to perform true $C = A{\cdot}B$ in the outer product, time-integrating regime originally proposed by Athale and Collins (1982). The key contribution is the replacement of kilohertz-rate liquid-crystal or acousto-optic modulation with gigahertz-rate electro-optic phase modulation on CMOS-integrated TFLN, exploiting the Fourier shift theorem to route arbitrary row/column pairs onto a 2-D time-integrating focal-plane array in a single electronic cycle. We derive the architecture from first principles, illustrate the scan trajectory on $3{\times}3$ example matrices, and analyze scalability against MZI meshes, WDM microring arrays, acousto-optic deflector (AOD) outer product processors, and NVIDIA H100 GPUs. For $N = 1024$, the proposed system projects 2 PFLOPS throughput at sub-10 fJ/MAC — a 30–100$\times$ improvement over contemporary photonic tensor cores at the same dimension — while retaining 6–8-bit analog precision adequate for transformer inference. We identify three technology gaps (precision, reconfiguration speed, electrical–optical I/O) whose simultaneous closure is necessary for deployment and quantify the expected timeline for each.

ID: 96

Are Thin Film Devices Ready for Biomedical Optoelectronics?

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Biomedical optoelectronics is a rapidly evolving field that integrates optical and electronic technologies to enable advanced diagnostic, therapeutic, and monitoring tools in medicine. It plays a crucial role in applications such as imaging, biosensing, and light-based therapies, where high sensitivity, miniaturization, and biocompatibility are essential requirements.

Thin film devices offer several advantages that make them particularly attractive for biomedical optoelectronics. Their reduced thickness enables lightweight integration and compatibility with unconventional substrates, while also supporting low-cost, large-area fabrication. These properties make them suitable for compact and potentially flexible systems that can interface with biological environments.

These features open the way to a wide range of applications, including photodetectors for wearable health monitoring, implantable optical sensors for real-time physiological measurements, and compact light sources for phototherapy and optogenetics. As material quality and device performance continue to improve, thin film technologies are expected to contribute significantly to the next generation of biomedical optoelectronic systems.

In addition, thin-film technologies based on hydrogenated amorphous silicon (a-Si:H) provide a mature and reliable platform for large-area photodetectors and imaging arrays, widely used in medical imaging systems such as flat-panel X-ray detectors. Their compatibility with low-temperature deposition processes enables integration on diverse substrates, supporting the development of scalable optical sensing systems. Furthermore, recent studies have explored a-Si:H devices for bioelectrical and optical sensing at the cellular level, highlighting their potential in biointerfaces.

Beyond these aspects, the talk will address the main challenges associated with the use of thin film devices in biomedical applications. In particular, it will focus on a-Si:H photosensors and temperature sensors, highlighting their suitability for the detection of celiac disease epitopes and viruses in lab-on-chip platforms.

ID: 97

Optical System Design and Performance Analysis of a Star Tracker

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This study presents the design of a star tracker in accordance with performance requirements, such as a 14.75° field of view, a 5.5 µm pixel size, an 11.26 mm x 11.26 mm sensor size, a 480-800 nm spectral range, and an effective focal length of 43.07 mm. The optical design of the star tracker system that will operate in Low Earth Orbit consists of 7 spherical lenses. The total length, aperture diameter, and total weight of the system are 62.98 mm, 27 mm, and 56.51 g, respectively. SF6 and CaF2 are chosen as lens materials based on their flint–crown balance to minimize chromatic aberration, and their radiation-resistant features to endure space conditions. A chain code algorithm is developed to perform SNR analysis; in this way, the minimum aperture size is determined to be 24 mm in order to capture enough signal for cold stars. Furthermore, the aperture stop is placed after the third lens, around the middle of the lens system, to achieve symmetrical spot distribution. Once the design is completed, image quality analysis is performed, spot diagram and encircled energy outcomes are evaluated. RMS spot radii of the optical design are around 4 µm, and GEO radii are around 8 µm. Encircled energy values are above 75% on a single pixel and 98% on the approximately 3x3 pixel area. The energy distribution of the captured light is spread over 3x3 pixels, so that the centroid of stars can be measured precisely.

ID: 98

A Stability Enhanced EDF Ring Laser Interrogator for FBG Sensing: Linear Response, Low Cost Design and Practical Optimization

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Fiber Bragg Gratings (FBGs) are widely used in structural health monitoring, yet the high cost and complexity of commercial interrogation units limit their deployment in small scale infrastructures. This work presents a compact and low-cost interrogation technique based on an Erbium Doped Fiber Laser (EDFL) in a ring cavity configuration, where the FBG sensor is embedded directly in the cavity [1]. By selecting FBGs with Bragg wavelengths within the 1532–1537 nm region—where the EDF amplified spontaneous emission exhibits a strong linear slope—the strain induced wavelength shift is converted into a linear variation of the laser output power, eliminating the need for tunable lasers or spectrum analyzers.

The system is evaluated through numerical modeling, laboratory measurements and prototype implementation. Experimental results demonstrate sensitivity up to 1.8μW/100 με and dynamic ranges exceeding 2000 με, while the use of narrower FBGs significantly reduces mode hopping and jumping effects, improving resolution below 10 με. A dual FBG configuration with an optical switch enables temperature compensation and long-term stability.

During cavity optimization, low-frequency power fluctuations were observed and attributed to weak parasitic reflections within the coupling section of the ring. A revised coupling scheme effectively suppressed these etalon-induced variations without altering the core operation of the interrogator, enabling stable performance across the full dynamic range.

The overall results demonstrate a compact, low-cost and scalable interrogation platform capable of achieving strain resolution better than ±2 με using a block-based double filtering technique. The simplicity of the topology, combined with its robustness and minimal component requirements, makes the system well-suited for long-term deployment in civil structures and small-scale infrastructures where conventional interrogation units are impractical.

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ID: 99

Digital Holographic Microscopy for Tissue Analysis across Malignancy Grades: A Label-Free Approach to Cancer Diagnostics in Digital Pathology

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Digital Holographic Microscopy (DHM) is a powerful tool for label-free visualization of transparent specimens, from cells in their natural environment to unstained tissue samples. Various morphological characteristics, optical properties, strength of attachment, growth rate, etc. can be extracted from the quantitative phase image (QPI), a particular image type that contains in each pixel the phase shift value induced by a transparent sample in the transmitted light. Use of endogenous biomarkers for unstained samples is beneficial, reducing chemical exposure and time-to-diagnosis in Pathology.

A cancer grading method using QPIs and machine-learning models (ML) was developed for tissue samples of colonic lesions. HoloPath, a digital library of QPIs for 5 morphologies of colonic adenomas was produced using DHM®-T1000 (Lyncée Tec, Switzerland) digital holographic microscope in transmission, in off axis configuration. Bright field microscopy images were collected from consecutive tissue sections of each tissue sample, having standard staining (H&E, Van Gieson, and immunohistochemistry), to be used as reference. Numerous statistical, textural, and morphological parameters of cells and histologic structures were extracted in correlation with the standard criteria for diagnosis.

Unsupervised algorithms (for identification histological structures) and supervised algorithms (for dysplasia grading, mapping of suspicious invasion/ desmoplastic/ inflammation areas, and score based diagnosis of malignant from benign or inflammation) were implemented using MLNet/Auto ML framework, until reaching an overall accuracy of 86%. A Graphical User Interface was implemented in MATLAB/ Python for a facile integration of the procedure into the routine Pathology clinical setup.

Our studies shown that biomarkers extracted from QPIs can be used to develop objective computer-assisted workflows for an early and accurate cancer diagnostic, in conditions of large volumes of samples.

Keywords: digital holographic microscopy, cancer grading, label-free biomarkers, colonic adenocarcinoma

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ID: 100

Advancing Optical Astronomy at ESO: Portuguese Contributions from the Institute of Astrophysics and Space Sciences

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Light is a fundamental tool for understanding the Universe. Advances in optical instrumentation and the analysis of stellar light have enabled the discovery of thousands of exoplanets and opened new windows on key galactic, extra-galactic, and cosmological questions. From probing the origins of the Universe to searching for Earth-like worlds, these scientific goals continue to drive the development of cutting-edge instruments for the world's most advanced ground-based observatories.

This presentation reviews the past, present, and future contributions of the Portuguese Institute of Astrophysics and Space Sciences (IA), to optical astronomical instrumentation at the European Southern Observatory (ESO), located in the Atacama Desert, Chile. We highlight the role of Portuguese teams in the development and operation of high-precision instruments at the Very Large Telescope (VLT), including the ESPRESSO spectrograph, which combines the light of four 8-meter telescopes to achieve unprecedented stability and sensitivity.

We will also showcase MOONS, the Multi-Object Optical and Near-infrared Spectrograph for the VLT, currently being installed at the observatory. This instrument will be capable of simultaneously observing nearly 1000 targets, feeding a large number of optical fibres that can be positioned at user-defined locations on the Nasmyth focal plane using individual robotic positioners. The selected sub-fields are then transmitted via the fibres to two identical cryogenic spectrographs mounted on the Nasmyth platform of one of the ESO VLT 8-meter telescopes.

Looking ahead, we present ongoing work on ANDES, a next-generation high-resolution spectrograph for the Extremely Large Telescope (ELT), a 40-meter-class facility expected to begin operations by the end of this decade.

Theses instruments pose significant technological challenges, involving optical systems, some approaching 100 meters in scale and others with large-aperture components with diameters close to one meter.

The talk will focus on the key challenges, innovative solutions, and scientific capabilities enabled by these developments, illustrating the impact of Portuguese contributions to the forefront of optical astronomy and photonics.

ID: 102

Simulation of optical transmission through planar multilayer dielectric stacks on silicon substrates: a comparative analysis between three numerical approaches

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Optimizing the spectral response of p-n junction silicon photodiodes fabricated in CMOS technologies requires precise knowledge of the optical behaviour of the multilayer dielectric stack, inherent to the CMOS fabrication process, deposited on top of the silicon substrate. It features reflection and interference phenomena defining the fraction of light reaching the photodiodes' active area. As these layers cannot be modified by the designer, accurate modelling of their optical impact is essential for reliable performance prediction within process constraints. This work presents a comparative study of numerical approaches for simulating the optical transmission through planar multilayer dielectric stacks on silicon, representative of two standard CMOS technologies: TSMC 65 nm and TSMC 180 nm. Briefly, the first has 44 layers of 5 different dielectric materials and the last 14 layers of 4 different dielectric materials. Three distinct modelling strategies were evaluated: Ray Optics and Wave Optics, using COMSOL Multiphysics; and thin-film interference, using TFCalc. They rely on fundamentally different physical descriptions of light propagation, ranging from geometrical optics and full-wave electromagnetic simulations to transfer-matrix methods, respectively. The simulated results show a clear distinction in the transmittance profile across the wavelength range from 400 nm to 1000 nm, for the TSMC 65 nm and TSMC 180 nm, with the latter exhibiting the greater intensity. In each technology, throughout the simulated wavelengths range, the transmittance value oscillates substantially, yet with excellent agreement among all three numerical approaches. This convergence confirms that the optical behaviour of these structures can be accurately predicted, although Wave Optics simulations required around 4 hours to compute, whereas the two other models were notably more computationally efficient. Ray-tracing approaches reduced the simulation time to roughly 40 seconds, and TFCalc outputted results in under 1 second, all while successfully capturing the necessary transmittance profiles. This study validates that simplified methods provide accurate, rapid predictions of optical transmission in standard CMOS stacks. These findings establish practical guidelines for efficient design resources, simulation, and spectral analyses of standard CMOS silicon photodiodes.

ID: 103

Friction Behaviour of Femtosecond Laser Textured DLC Coatings

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The aim of the present work was to investigate the influence of femtosecond laser surface texturing on the friction behaviour of DLC coatings. The laser treatments were carried out by overlapping consecutive laser tracks created by moving the samples under the

stationary laser beam. The textured surfaces consisted of a combination of microscale asperities located at the centre of the laser tracks and sub-micron laser-induced periodic surface structures (LIPSS) formed in the peripheral regions. Tribological tests were performed on polished and textured samples, in air, using a ball-on-plate tribometer to evaluate the friction coefficient. The results revealed that the laser-textured films exhibited a higher coefficient of friction (COF) under unlubricated (dry sliding) conditions than the polished surfaces. This behaviour can be attributed to the partial disruption of the DLC films at the centre of the laser tracks, which diminished the potential beneficial effects of wear debris entrapment and reduced contact area, typically associated with surface texturing.

ID: 104

Modulation of Pupillary Constriction by Commercial LED: Effects of CCT and background Luminance

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The increasing of LED technology has raised concerns about its potential effects on visual performance. However, limited information is available regarding the influence of glare from LEDs with different correlated colour temperatures (CCTs) on pupillary diameter dynamics. While previous studies have examined the effects of monochromatic LEDs on pupillary dynamics, the impact of commercially LED lamp has not yet been investigated. Therefore, this study aims to evaluate the effect of CCT from these LEDs on pupillary behaviour under glare.

Measurements were performed using a pupillometer view optical system projecting a 10o adaptation field from a 4000 K LED source at three luminance background levels: 0.1, 1, and 10 cd/m2. A glare stimulus of 52 lux was presented for 3 s at 10o on the temporal retina using two LED sources with CCTs of 2700 K and 6500 K, randomly presented. Eye position and Pupil light reflex index (PLRI) were recorded using a Camera Alvium 1800 U-501 NIR-based infrared pupilometer integrated into the optical system. Nine young participants (18–30 years), free of ocular pathology, with refractive errors of less than $\pm$6.00D and normal colour vision, participated in the experiment.

The results showed that background luminance significantly affected pupil constriction. Both, baseline pupil diameter and constriction amplitude, were significantly greater under low luminance conditions. The 6500 K LED lamp produced greater pupil constriction than the 2800 K lamp, suggesting that correlated colour temperature influences the amplitude of pupil constriction.

Higher background luminance reduced baseline pupil diameter and constriction amplitude, likely because the pupil was already partially constricted due to the tonic light reflex, limiting the degree of constriction achievable during glare exposure.

Photoreceptor excitation analysis of the glare source, calculated using equivalent daylight illuminance (EDI) lux, revealed a greater contribution from S-cones and rods, photoreceptors involved in pupil constriction during glare exposure. A high contribution from melanopsin-containing intrinsically photosensitive retinal ganglion cells (ipRGCs) was also observed, likely associated with the sustained component of the pupillary response during the 3 s stimulus. Additionally, at 10 cd/m2, a smaller post-illumination pupillary response (PIPR) was observed when the lamp had higher short-wavelength content.

ID: 105

Colour Temperature and Glare in Pseudophakic with Depth-of-Focus Lenses

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The number of pseudophakic subjects implanted with extended depth-of-focus (EDOF) intraocular lenses has increased steadily in recent years, representing a growing segment of the population. These lenses, designed to provide an extended range of functional vision and reduce spectacle dependence, exhibit specific optical properties that may influence visual quality in the presence of glare. It has been suggested that spectral characteristics of light sources, such as correlated colour temperature (CCT), could modulate disability glare, potentially affecting visual performance in these patients. However, to date, there are no studies assessing the visual behaviour of pseudophakic subjects with EDOF intraocular lenses when exposed to glare from light sources with different CCT.

Sixteen pseudophakic subject participated in the study. A two-channel Maxwellian optical vision system was used to measure foveal reaction time without and with a glare presented at a temporal retinal eccentricity of 10°. A 2o stimulus with a Weber contrast of 0.1 was used, presented over a background field with two different luminances, 0.1 and 1 cd/m2, provided by a LED lamp with a correlated colour temperature of 4000 K. Glare source was produced by two LED with correlated colour temperature of 2800 and 6500 K, providing an illuminance of 50 lux.

In the glare condition, reaction time is significantly lower for the background luminance of 1 cd/m2 respect to 0.1 cd/m2, for both 2800 K ($p < 0.05$) and 6500 K ($p < 0.05$) lamps. No effect of correlated colour temperature is found on reaction time measurement for 0.1 cd/m2 ($p = 0.11$) and 1 cd/m2 ($p = 0.89$).

Our results indicate that this pseudophakic population shows a comparable glare response, as reflected by similar increases in reaction time. The absence of a CCT-related effect could be explained by several factors. First, the macular pigment concentrated in the foveal region likely absorbs a substantial portion of the short-wavelength light emitted by the 6500 K source. Second, the clarity of the ocular media in these participants may limit intraocular light scatter. Finally, it is also plausible that CCT is not the most suitable parameter for predicting glare associated with this type of LED technology.

ID: 106

Optoelectronic Study and Optimization of a Hybrid Nanograting-Enhanced GaAs MSM Photodetector with Metallic Adhesion Layers

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Gallium arsenide (GaAs) metal–semiconductor–metal (MSM) photodetectors are attractive for different applications, especially high-speed optical sensing. However, their performance is often limited by the low optical absorption near the GaAs operating band. In this work, a three-dimensional finite element method framework based on COMSOL Multiphysics has been employed to enhance the optical and optoelectronic response of GaAs MSM photodetectors through hybrid plasmonic–cavity nanograting engineering.

Firstly, the grating placement effect has been evaluated by comparing four configurations: grating-free, top-grating, down-grating, and combined top–down grating structures. The top–down configuration has been identified as the most efficient design, reaching a near-unity near-infrared absorptivity peak of 0.998 around 791 nm. A structural optimization has then been performed by studying trapezoidal and elliptical groove profiles with different aspect ratios. The results have shown that controlled groove shaping improves near-field confinement and strengthens the hybrid plasmonic–cavity absorption response within the GaAs detection-relevant spectral range.

To account for practical fabrication constraints, titanium (Ti) and chromium (Cr) adhesion layers have been integrated into the optimized top–down structure. The Ti/Cr thickness sweeps show that these interlayers modify the resonance position, bandwidth, and absorption strength through additional optical damping. Ti layer has been found to preserve the near-infrared (NIR) response better than the Cr one at a comparable thickness, indicating a more favorable trade-off between optical performance and stability adhesion. Finally, coupled electromagnetic–semiconductor simulations have been implemented to evaluate the device-level photocurrent and responsivity. Compared with the grating-free reference, the optimized hybrid nanograting structure provides a strong photocurrent enhancement, reaching an 18.8-fold increase in the peak photocurrent. In addition, a properly engineered Ti adhesion layer sustains a peak responsivity of approximately 63 mA/W near the GaAs band edge. These results provide practical guidelines for the development of mechanically robust and high-efficiency hybrid plasmonic GaAs MSM photodetectors.

ID: 107

BathLiDAR: Privacy-Preserving Bathroom Fall Detection with a Single ToF Sensor

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Bathrooms remain the highest-risk indoor environment for older-adult falls, yet dominant detection modalities are each a poor fit: cameras violate privacy and degrade under steam; wearables suffer compliance gaps during showering; millimeter-wave (mmWave) radar is costly with limited resolution. Multi-zone single-photon time-of-flight (ToF) sensors offer a privacy-preserving, low-cost alternative, but no published bathroom system has explicitly addressed steam, droplet, and cover-glass condensation, nor exploited the per-zone Compact Normalized Histogram (CNH) as a first-class signal.

This work presents BathLiDAR, a preliminary single-sensor multi-task monitor built on one VL53L8CH 8 by 8 ToF sensor (CNH at 15 Hz, 18 bins, 940 nm, 6108 bytes per frame over Serial Peripheral Interface) paired with an STM32N6 Cortex-M55 and Neural-ART neural processing unit (NPU) (600 GOPS INT8, 4.2 MB static RAM). Four contributions are integrated. First, a histogram-domain preprocessing pipeline combines exponential-moving-average baseline subtraction, ordered-statistic constant-false-alarm-rate detection, and parabolic sub-bin interpolation with a quadratic error bound, yielding about 16 mm precision against a 300 mm bin. Second, MCFNet-N6, a 180k-parameter, 8 mega multiply-accumulate-per-frame dual-branch network, fuses a 1-D histogram branch with a depth-summary branch under squeeze-and-excitation gating, followed by depthwise-separable spatial encoding and a 16-frame causal temporal convolutional network, emitting four heads: segmentation, posture, activity, anomaly. Third, a software-only graceful-degradation finite-state machine drives a four-component score with hysteresis through levels L0 to L3, monotonically restricting tasks rather than failing silently. Fourth, a two-stage fall detector, a 3-frame moving-average trigger plus extreme gradient boosting confirmer over a 45-frame ring buffer, bounds confirmation latency below 1.33 s with probability at least 0.99.

Simulation-based evaluation on 60k synthetic CNH frames spanning steam extinction up to 5 per meter, plus a planned 10-subject 300k-frame study, projects 99.1 percent fall sensitivity at 0.18 false alarms per day, 0.81 segmentation intersection-over-union, 47 ms end-to-end latency at 138 mW, and graceful operation through L2 where depth-only baselines collapse. Single-sensor, fully on-device bathroom monitoring is feasible within a microcontroller plus NPU envelope at the 66.7 ms frame budget.

ID: 108

Five Wavelengths, Five Distances : A Concentric Structured-Light Sensor for Long-Range Forward Profiling in Gas Pipelines

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Pipeline Inspection Gauges (PIGs) in 36-inch gas pipelines need long-range forward awareness of bends and branches to brake safely at cruise speeds, but single-wavelength laser profilers reach only sub-meter. We propose a five-wavelength concentric Structured-Light (SL) sensor that encodes wavelength as forward distance, validated by simulation as a feasibility study.

A wavelength-selective Diffractive Optical Element (DOE) array projects five visible rings within the Multi-Spectral Filter Array (MSFA) camera band of 430–700 nm. The wavelengths, refraction angles, and ring impact positions are: 450 nm at 2.58° at 10 m; 488 nm at 3.69° at 7 m; 561 nm at 6.43° at 4 m; 635 nm at 12.71° at 2 m; 690 nm at 24.28° at 1 m.

Inference combines Hessian sub-pixel line extraction, direct least-squares ellipse fitting, a marginalized Random Sample Consensus (RANSAC) estimator, an Extended Kalman Filter (EKF) tracker, and an affine-normalized figure-eight topology prior. Dust follows the Beer–Lambert law with Ångström dependence, valid in weak-scattering regimes; high Optical Thickness (OT, the dimensionless extinction–path-length product) needs conservative interpretation.

Four geometries were tested by Monte Carlo (MC) simulation: straight, 45° elbow, 90° elbow, T-junction through, and T-junction end. Straight pipes form the baseline with sub-millimeter accuracy and no shape-change trigger. A 45° elbow first triggers the long-range channel via mild monotonic eccentricity at about 10 m. A 90° elbow yields a sharper pattern at the same range. T-junction through opens a side aperture; self-intersecting figure-eight topology emerges on the long-range ring near 10 m. T-junction end terminates the bore: the long-range ring fails to close while short-range rings collapse against the dead-end wall, giving the strongest emergency-stop cue.

Dust attenuates short wavelengths first. Light loading (OT below 0.2) preserves all rings and keeps recognition near 10 m. Moderate loading (OT 0.2–0.7) with mineral dust drops recognition to 7 m; with iron oxide or organic films, blue-end attenuation is stronger and recognition drops to 4 m. Heavy loading (OT above 0.7) with smoke or soot leaves only red-end channels, shrinking recognition to 2 m at 635 nm or 1 m at 690 nm.

The sensor offers feasibility-grade forward awareness up to 10 m for all four geometries under clean conditions, degrading gracefully under dust. Bench validation, mock-up loops, and certification remain future work.

ID: 109

Ion Beams for Materials Processing and Characterization

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Wide-bandgap semiconductors are widely used in light-emitting diodes and lasers and are increasingly attractive for high-power and high-temperature electronics. Their chemical and thermal stability, combined with strong radiation resistance, makes them promising alternatives to conventional silicon technologies for operation in extreme environments, including space. In addition, their high optical transparency makes them suitable hosts for optically active ions, such as rare-earth and transition-metal dopants, with applications ranging from optical sensors to quantum emitters.

Ion implantation offers a versatile route to incorporate such dopants into wide-bandgap materials. It enables doping beyond equilibrium solubility limits, controlled depth profiles, and lateral patterning. However, our recent studies have revealed complex defect formation in wide-bandgap semiconductors, highlighting the need for a detailed understanding of implantation-induced damage and its recovery. Such knowledge is essential for the reliable integration of ion implantation into semiconductor processing.

In this presentation, we will discuss ion implantation in III-nitride thin films and nanostructures, as well as the effects of ion irradiation on III-nitride-based radiation sensors. We will also show how ion beams can be used deliberately for defect engineering. Examples include modifying Ga2O3 to enhance chromium-related emission and using ion-beam-induced exfoliation to fabricate microrolls and thin membranes.

Beyond presenting our recent work on wide-bandgap semiconductors, this talk aims to illustrate the broader potential of ion beams in materials science. Ion beams provide powerful tools not only for modifying materials and tailoring their functional properties, but also for characterization through ion beam analysis. These approaches are applicable to a wide range of material systems and can provide valuable insight and inspiration for researchers across optics, photonics, and advanced materials science.

ID: 110

Phase-Change Materials as an Enabling Platform for Memory-Enabled Silicon Photonics

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The rapid growth of data-centric technologies has pushed conventional electronic architectures toward fundamental limits in bandwidth, energy efficiency, and latency. Silicon photonics has emerged as a compelling platform to overcome these challenges through CMOS-compatible technology. However, the absence of efficient, scalable memory within photonic systems remains a critical bottleneck, limiting their ability to perform complex, state-dependent operations.

This talk explores the role of memory in photonic architectures, highlighting why integrating memory functionalities directly into photonic platforms is essential for next-generation computing and communication systems. From a materials perspective, the realization of photonic memory is constrained by the lack of strong, reversible, and energy-efficient optical nonlinearities in conventional materials.

Phase-change materials (PCMs) provide a promising solution to these challenges. By exploiting their ability to reversibly switch between distinct structural phases with large optical contrast, PCMs enable reconfigurable photonic functionalities. We discuss how different classes of PCMs can be engineered to tailor switching dynamics, optical loss, and endurance, thereby addressing key limitations in silicon photonics.

A central theme of this work is the distinction between volatile and non-volatile photonic memory, and how specific applications—from neuromorphic computing to programmable photonic circuits—demand different material responses. We further examine the evolution of PCM-based photonic devices, outlining recent advances and identifying the remaining challenges in scalability, integration, and speed.

ID: 111

From Bacterial Fingerprints to Renal Biomarkers: Deep Learning in Raman Spectroscopy

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Raman spectroscopy is a photonic technique that produces a unique molecular fingerprint for each substance, requiring minimal sample preparation and no labelling. These properties make it particularly attractive for biomedical diagnostics, where fast and non-invasive analysis is needed.

However, interpreting Raman spectra manually is time-consuming and requires specialized expertise. Integrating artificial intelligence addresses these challenges by enabling real-time identification of substances with high precision.

In this work, we implement a lightweight residual 1D convolutional neural network inspired by RamanNet and trained on the RamanSPy benchmark dataset containing over 60,000 spectra from 30 bacterial and yeast isolates responsible for the majority of intensive care infections. This dataset was chosen because it represents one of the most complete publicly available resources for deep learning in spectral diagnostics, allowing direct benchmarking against existing methods. A transfer learning approach was applied, where the model is first pre-trained on the full reference dataset to learn general spectral features, then fine-tuned on smaller data subsets using stratified k-fold cross-validation. The best model reached 83.4% classification accuracy across the 30 isolates.

Beyond bacteria, the same framework is being extended to urine analysis for early detection of Acute Kidney Injury (AKI). The rationale is that a model trained on large bacterial spectral data learns the underlying language of Raman signatures, which can then be adapted to detect subtle biochemical changes in urine, such as altered levels of creatinine, urea, and proteins, before morphological damage becomes visible. Clinical sample collection is ongoing, and preprocessing pipelines for urine spectra have already been developed.

This project integrates biophotonics and medical AI to develop a reliable, low-cost diagnostic tool compatible with portable photonic systems.

ID: 112

Investigation of the Nonlinear Response of Photonic Crystals for Applications in Laser Protection Systems

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A major vulnerability for optical sensors, imaging and vision systems is posed by laser radiation, above all from Nd:YAG lasers operating at 1064 nm and its second harmonic, 532 nm. At these two wavelengths, conventional passive protections still fall short. Among the various solutions that have been explored, optical limiting stands out as one of the most promising approaches.

In this work, we introduce a novel optical limiter design based on a two-dimensional photonic crystal, which consists of a square lattice of circular rods made of a Kerr nonlinear material surrounded by air. The design merges a photonic crystal's periodic dielectric modulation, which creates photonic bandgaps that block specific frequencies, with the optical Kerr effect, which induces additional refractive index shift $\Delta n = n2 \cdot I$, where n2 is the material nonlinear index and I is the laser intensity. Their combination makes the bandgap position intensity-dependent, so that the same crystal can be transparent at low power and opaque at high power at the target wavelength.

We have carried out an optimization procedure to determine the optimal design parameters under the constraint of the desired operation. At low incident intensity, the crystal is designed to be spectrally transparent in the visible and NIR ranges, allowing light propagation with minimal attenuation. At high incident intensity, the Kerr effect shifts the refractive index of the rod material which modifies the photonic band structure and opens a forbidden gap precisely at 1064 nm, thereby reflecting or extinguishing the high-power beam. This transition from transparent to opaque is entirely passive, instantaneous, and reversible since the crystal returns to its transparent state as soon as the intensity drops below the threshold.

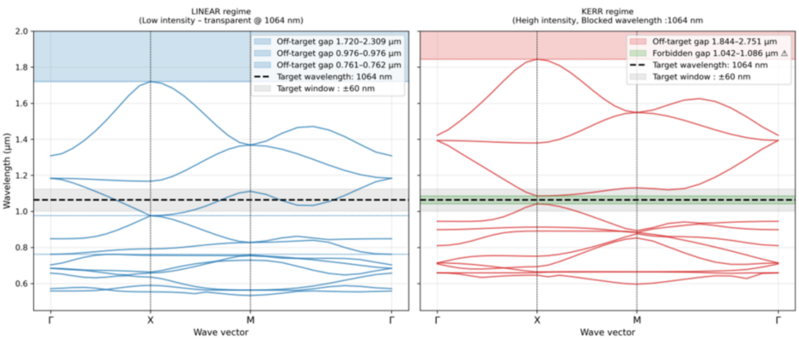

Figure - The calculated band diagram: (left) linear regime, and (right) nonlinear regime.

ID: 113

Nanowires for Enhanced Biosensing: Tapered Geometry to Improve Fluorescence Signal and Imaging

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Optical biosensors are of great interest over electrochemical, electrical, or piezoelectric sensors because they offer exceptional sensitivity, allow label-free or fluorescence-based detection, and real-time monitoring. Industry-standard planar biosensors are popular for their simplicity and cost-effectiveness, but are often limited by sensitivity and detection limits. Nanowire (NW) biosensors are currently attracting significant attention because their high surface-to-volume ratios and engineered geometries that enhance light-matter interaction, and photon collection, enabling ultra-low-concentration biomolecule detection that surpasses conventional planar sensors.

Recently, our group showed through modelling that vertically placed GaP nanowires can enhance fluorescence excitation, photon collection, and quantum yield (via the Purcell effect), leading to >100× signal enhancement over planar biosensors. It also enable imaging-based detection with up to 25-fold sharper images than conventional diffraction-limited microscopy.

We introduce here a vertically aligned tapered NW to enhance signal quality, by improving local excitation intensity and photon collection, as well as imaging performances. A tapered section is placed at the top of the cylindrical NW to enhance light concentration, while the fixed cylindrical base retains the main optics benefits found in the earlier study. Here, we develop and apply modelling approaches for the design and analysis of tapered nanowire-based fluorescent biosensors. The optimized nanowire configuration renders improvement in signal enhancement, increasing as the tapering length to second order, over the recently published cylindrical nanowire design. For example, with a taper length of 8500 nm, the signal enhancement is approximately 10-fold higher than that of the non-tapered configuration across all tested fluorophore quantum yield values. Based on our analysis this low-NA, non-imaging detection scheme is well suited for compact, field-based diagnostic systems. To assess imaging performance, we developed modelling approaches to analyze imaging scenarios in detail, achieving 15% higher image sharpness than a cylindrical nanowire.

Overall, our research demonstrates through comprehensive design and modelling that tapered nanowire biosensors could outperform conventional planar designs by orders of magnitude, by enhancing local excitation intensity, fluorescence signal collection, Purcell factor, and imaging performance.

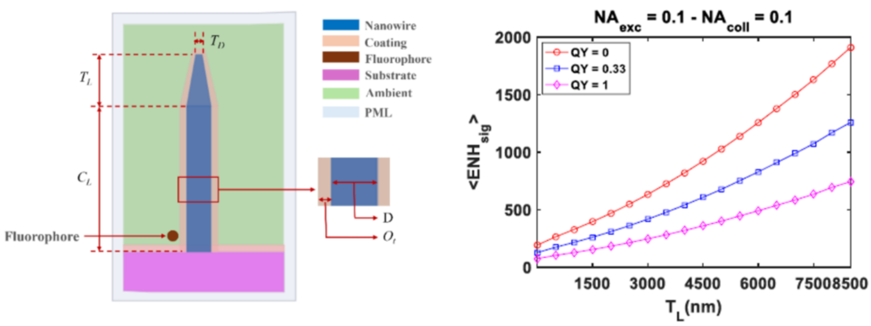

Figure - Left: Cross sectional view of Proposed Tapered Nanowire with main geometrical parameters indicated. Right: Signal enhancement relative to the planar biosensor as a function of tapering length at low numerical aperture

ID: 114

Precision sight: The Optics behind the intraocular lens

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Looking beyond the cataract reveals a multidisciplinary challenge where optics meets surgical innovation. Modern cataract surgery has transitioned from a rehabilitative procedure into a refractive intervention, restoring ocular transparency while simultaneously correcting myopia, hyperopia, and astigmatism. This presentation addresses the optical principles of contemporary intraocular lenses (IOLs), specifically focusing on designs that extend the depth of focus to address presbyopia.

IOL performance is evaluated through two complementary methodologies: in-vitro laboratory testing and in-vivo clinical assessment. Correlating these distinct metrics facilitates increasingly accurate predictions of postoperative visual outcomes. Furthermore, this framework underscores the need to provide ophthalmologists with qualified, high-fidelity optical data. As IOL designs become progressively sophisticated, a robust background in optics is highly advantageous for clinicians to effectively navigate these technologies. This technical expertise is necessary for personalized implant selection, ensuring that the chosen optical design aligns with the patient's characteristics and lifestyle requirements.

ID: 115

Optimization of a fluorescence sensing setup for water contaminants

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Safeguarding water quality requires the detection of contaminants [1] and this is a growing topic in environmental monitoring management [2]. The conventional methods for water monitoring are based on sample collection, preservation and preparation, while the analysis is done by laboratory testing. These methods have a high cost and high maintenance, laborious procedures, and are not practical for field testing [3].

There is the need for rapid, portable, low-cost, and user-friendly detection method [4]. Sensor approaches offer the potential for fast, on-site detection to evaluate water sources for PFAS exposure [5]. Optical sensors, in particular, use the interaction of light with the target analyte to produce a measurable optical signal. These are normally developed with optical fibres allowing to pursue important characteristics such as: small size [6], low cost, long distance, immunity to electromagnetic fields, light weight [6] and ease of use. Fluorescence sensors are one class of optical fiber sensors with recognized importance, and providing good sensitivity to detect water contaminants [1].

In this work, optical configurations for fluorescence-based sensing are discussed, aiming to target water contaminant detection.

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ID: 116

All-optical reservoir computing enabled by luminescent materials with intrinsic synaptic dynamics

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Artificial intelligence is redefining society and motivating an unprecedented demand for computational power, motivating the development of neuromorphic architectures that emulate key principles of information processing in the human brain.[1] Photonics offers an effective route towards such alternatives, providing intrinsic parallelism and high bandwidth, enabling neuromorphic architectures in which computation and memory occur directly in the optical domain. Among neuromorphic approaches, reservoir computing (RC) has attracted significant attention due to its ability to exploit the transient dynamics of high-dimensional nonlinear systems for temporal information processing. Its key advantage lies in the simplified training scheme, where only a readout layer is optimized, making it particularly attractive for physical implementations with reduced computational overhead. Nonetheless, the realisation of RC that operates solely through light with neuromorphic features remains in its early stages.[2]

Here, we introduce a photonic neuromorphic computing paradigm in which the RC functionality is intrinsically embedded within a luminescent material. The material exhibits dual fluorescence–phosphorescence emission and excitation-history-dependent photoactivation dynamics, enabling the emulation of key synaptic behaviours such as short- and long-term memory and synaptic potentiation. We demonstrate this concept using a boron-based organic material, which was prepared through a simple thermal treatment from a commercially available organic molecule precursor in the presence of boric acid. Under pulsed optical excitation, the material performs temporal feature transformation through its inherent fading memory and nonlinear response. When applied to the MNIST image recognition tasks, the system achieves a test accuracy above 90% while reducing computation time by approximately 50% compared to fully digital artificial neural networks.[3] These results establish luminescent photonic materials as a promising platform for embedding neuromorphic functionalities, opening new avenues toward efficient, adaptive, and fully optical computing systems.

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ID: 117

Experimental Techniques for Measuring MTF

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Spatial resolution is a fundamental characteristic of any imaging system. The method that it is used to evaluate the spatial resolution of an imaging system is the Modulation Transfer Function (MTF), a metric that provides a standardised and quantitative way to characterise optical systems and reflects how it reproduces contrast as a function of spatial frequency. While the system response at high spatial frequencies determines its ability to render fine details and sharp edges, high contrast transmission at low spatial frequencies ensures the accurate reproduction of large structures within the scene. Besides its importance, the MTF is currently evaluated for on-axis illumination, having no clear method on how to relate on-axis MTF measurements with illumination from different fields.

This work presents two complementary pipelines for the experimental measurement of the Modulation Transfer Function (MTF) for different fields. The MTF is calculated using the two most common methods: the slanted-edge method and Siemens stars. Together, these methods enable an objective assessment of optical system quality by quantifying how effectively contrast is preserved across different spatial frequencies. To do so, we first validated the pipeline by generating slated edge and Siemens star artificial images. The artificial images produced were initially used for pipeline development and testing, as they closely resemble the expected experimental results, while offering reduced noise levels and a variety of adjustable target features. In addition, these artificial images were employed to cross-calibrate the two techniques and prepare them for subsequent experimental data analysis.

The slanted-edge method was correctly tested with images obtained in a laboratory setting, while the experimental test of the Siemens star pipeline is still in progress. In the future, the results obtained from the two methods will be combined to obtain complete datasets of the MTFs for different illumination fields.

ID: 118

Surface Plasmon Resonance (SPR) sensor study for contaminant sensing

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Surface Plasmon Resonance (SPR) based sensor is among the most widely used optical sensing architectures for chemical [1] and biomedical sensing [2], with potential for in situ measurement, real-time, and highly sensitive applications [3]. In this work, an SPR-based optical fiber sensor is investigated as a promising platform for detecting contaminants in aqueous media.The proposed approach aims to provide a rapid and cost-effective alternative to conventional analytical methods, which are often laborious, expensive, and dependent on complex laboratory instrumentation [4].

The work encompasses the development of an SPR sensor comprising a 40 nm gold layer deposited on a 1 cm unclad 200 µm thick multimode fibre. This SPR sensor was studied in transmission and reflection modes. To maximize SPR sensor sensitivity, the sensor was bent to different curvature radius, and its sensitivity to external stimuli was evaluated.

This work highlights the strong potential of SPR optical fiber sensor approaches for contaminant detection.

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ID: 119

Subclinical Ocular Effects of Digital Blue Light Exposure: An Integrated Optical and Functional OCT Study

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The widespread use of digital devices has significantly increased exposure to artificial blue light, raising concerns about its potential impact on ocular health. Despite growing awareness, clinical evidence of early ocular alterations in humans remains limited. This study investigates early functional and structural ocular changes associated with prolonged digital exposure, integrating tear film assessment, cornea and retina with optical coherence tomography (OCT).

A prospective longitudinal study was conducted in 48 healthy eyes from 24 habitual digital device users. Ocular surface function was evaluated using the Schirmer test and tear film break-up time (TBUT), while corneal and retinal structures were assessed using spectral-domain OCT. Measurements were obtained at baseline (morning and afternoon) and at long-term follow-up. Statistical analysis accounted for repeated measurements and intra-subject variability.

A significant dissociation between tear production and tear film stability was observed. TBUT showed a marked reduction at follow-up (−2.60 s; $p<0.001$), indicating impaired tear film stability, whereas Schirmer values increased slightly (+2.07 mm; $p<0.001$), suggesting compensatory reflex tearing. A clear diurnal effect was identified, with both TBUT and Schirmer values significantly reduced in the afternoon ($p<0.001$), consistent with cumulative ocular fatigue. Participants with higher daily screen exposure (>6 h/day) exhibited more pronounced TBUT reduction.

Corneal OCT analysis revealed stable pachymetric parameters with no significant structural changes over time. Retinal OCT demonstrated small but statistically significant reductions in central subfield thickness (−1.44 µm; $p=0.030$) and macular volume (−0.0458; $p=0.024$), while mean macular thickness remained unchanged. Higher OCT signal strength was associated with increased CST values, highlighting the influence of acquisition quality on retinal measurements.

Overall, prolonged digital exposure primarily induces functional alterations at the ocular surface, consistent with an evaporative dry eye pattern, while structural changes in deeper ocular tissues remain minimal and likely subclinical. TBUT emerges as a sensitive early biomarker of ocular surface impairment. These findings highlight the value of combining optical imaging and functional metrics to detect early ocular changes in modern digital environments.

ID: 120

A software tool for the alignment and characterization of cross-dispersed echelle spectrographs

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Cross-dispersed echelle spectrographs (CDES) are high spectral resolution instruments with great relevance in astronomy, with one of its uses being exoplanet discovery and characterization. Such instrument is highly sensitive to small, often uncontrollable, variations of their optical setup. To optimize its calibration method, a CDES must have a way to be characterized in its "as-built" configuration.

In this work, we develop a pipeline to retrieve spectrograph characteristics based on calibration images of the spectrograph. The approach here presented uses the generation of synthetic detector frames, including pixelized line profiles, used to test the pipeline. These frames are then put through a library-based matching process, where the libraries contain the theoretical frames information. This allows the retrieval of design parameters of the instrument, and hence its possible optimization. By analysing different calibration frames, it is possible to study different effects of angular parameters on the detector (such as the echelle inclination and off-axis angles). Inter-order spacing is used to estimate cross-disperser related parameters, while single spectral points are used for the estimation of the echelle's characterization. The influence of geometric perturbations, such as detector rotation and image-plane shifts, is also assessed with separate variables.

After validating the pipeline with synthetic images, we intend to test it with spectral images obtained with a benchtop CDES and evaluate the performance software with known perturbation This method will allow to know exactly how the instrument is designed, in its "as-built" state.

ID: 121

Tapered Erbium Fiber Laser Using FBG Mirrors

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Erbium-doped Fiber lasers (EDFLs) operating in the 1550 nm telecommunications window are foundational to modern high-capacity communications and optical sensing. The performance of these systems is inherently tied to their cavity architecture. Fabry-Perot cavities offer fabrication simplicity and high output power; bidirectional light propagation causes spatial hole burning and mode competition. In contrast, ring cavities solve these issues through unidirectional propagation but introduce architectural complexity and reduce output power. To combine the structural simplicity of linear cavities with enhanced photon-matter interactions capabilities, we present an FBG-stabilized linear EDFL integrated with custom adiabatic Fiber taper fabricated directly within the cavity. This modification exposes the evanescent field of the propagating light without compromising the cavity's resonant conditions. The fabrication process is based on a precisely controlled heat-and-pull technique. A 5-6 cm section of the active Fiber between the FBG mirrors is stripped and clamped under strictly regulated longitudinal tension on precision linear translation stages. Utilizing a custom ceramic microheater with a longitudinal slot aligned to the Fiber axis. The thermal profile is dynamically ramped from 600 oC baseline to a target drawing temperature of 1050-1100 oC. The linear stages then perform a slow, symmetric, bidirectional stretch. Throughout the pulling process, the optical transmission on the active laser cavity, is monitored in real-time utilizing an Optical Spectrum Analyzer (OSA). This continuous monitoring guarantees an entirely adiabatic transition, minimizing intracavity loss while preserving the structural integrity of the taper. Due to the significantly, higher intracavity power compared to the external output, the exposed evanescent field at the subwavelength, taper waist forms an ultra-sensitive interaction region. External refractive index fluctuations–driven by temperature, strain or specific target materials–directly alter the laser's resonant frequency for real-time, high-precision sensing. Beyond environmental sensing, this tapered cavity architecture provides a robust, low-loss optical bridge for quantum photonics, efficiently coupling intracavity laser light into solid-state micro-resonators and single-photon emitters.

ID: 122

Low-Cost Minimal RA Tracking System for Deep-Sky Astrophotography

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When capturing deep-sky objects at night, long exposures are required to collect sufficient light for a good final image. At high focal lengths, the Earth's rotation becomes noticeable, requiring right ascension tracking to prevent star trailing and enable unattended operation with high precision. Several open-source and commercial motorization solutions exist for equatorial mounts, including OnStep, AstroEQ, and various commercial kits. These systems share a common hardware foundation (microcontroller, stepper motor drivers, stepper motors) but differentiate themselves through software complexity, offering GoTo functionality, dual-axis control, integration with astronomy platforms, autoguiding, and wireless connectivity.

This work presents a deliberately minimalist alternative targeting a well-defined use case: constant-rate RA tracking for long-exposure astrophotography, without additional functionalities. The system was developed and validated on a Sky-Watcher EQ3-2 mount. Direct mechanical measurements of the mount were used to design a custom motor bracket in FreeCAD from scratch, manufactured via FDM 3D printing using standard PLA filament.

The electronics stack comprises a NEMA17 stepper motor for precision, a planetary gearbox providing extreme torque and precision at low speed, a TMC2208 driver for silent micro-stepped operation free of vibration, and an ESP32-C3 controller with a potentiometer for real-time fine- tuning of tracking speed.

The total component cost is approximately 27€, distributed across planetary gearbox (13€), stepper motor (5-8€), stepper motor driver (3.5€), microcontroller (4€), and printed components (<3€), representing an 85% cost reduction compared with commercial, feature-rich alternatives, while sharing the same fundamental hardware principles.

The system was validated through astrophotography sessions targeting different deep sky objects by stacking multiple 30 second exposures using Deep Sky Stacker and using GIMP for further processing. Results confirm that minimalist single-axis tracking is sufficient for long-exposure deep-sky imaging.

The mechanical bracket is specific to the EQ3-2 geometry. However, the complete methodology is fully transferable to other mount models. This work represents a viable and accessible approach to deep-sky astrophotography, providing a solution that performs only the essential function of sideral tracking, while leaving object finding and telescope pointing to the observer.

ID: 123

VLC-Based Traffic Coordination: Physical Layer Modeling and System Design

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Urban areas are increasingly affected by traffic congestion driven by rising vehicle density, particularly at major intersections during peak hours. This work proposes a shift from traditional Traffic Signal Control (TSC) systems, typically rigid, reactive, and vehicle-centric, towards an adaptive, communication-aware paradigm that is robust to real-world latency and noise in urban optical infrastructure while promoting social fairness.

Visible Light Communication (VLC) is explored as a key enabling technology, using existing LED-based infrastructure such as public lighting, traffic signals, and vehicle headlights to provide high-capacity, low-latency communication without requiring licensed spectrum. The proposed approach explicitly incorporates realistic channel impairments, including error correction mechanisms and calibration using real-world data.

The research focuses on the development and validation of a realistic VLC communication layer for traffic coordination. Initial efforts concentrate on spatial channel modeling and coverage mapping under atmospheric effects, establishing a calibrated simulation environment. In parallel, a signal processing and decoding pipeline is designed with emphasis on noise mitigation and synchronization to ensure reliable communication. These foundations enable the subsequent integration of robust V2X communication protocols and cyber-physical traffic control, including multi-agent reinforcement learning for adaptive signal coordination and fairness-aware optimization.

The proposed framework is validated through scalability studies and experimental laboratory evaluation, targeting Technology Readiness Level 4 (TRL 4). Risk mitigation strategies, including iterative calibration with real data and fallback mechanisms, are incorporated to ensure system robustness under adverse conditions. This work contributes to the intersection of photonics and intelligent transportation systems by demonstrating the potential of VLC to enable next-generation, resilient, and equitable urban traffic management.

ID: 124

Torsion Sensing in Optical Fibers via Polarization State Evolution

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Sensors are fundamental tools in our daily lives. Since the beginning of time, humans have sought to develop systems capable of measuring and describing physical quantities through mechanical and electromagnetic means. With the advance of technology, the need to improve and refine these systems has arisen. In this context, optical approaches have emerged as an alternative solution.

In this work, we propose the implementation of a simple system for torsion detection and quantification based on polarization. Several methods for torsion sensing in optical fibers have been reported, many of them relying on birefringence modulation and polarization effects.

Although these methods exhibit good sensitivity, they also present disadvantages such as complex implementation, impractical and expensive setups, and dependence on multiple parameters, requiring careful design and auxiliary systems to isolate the desired physical quantity, in this case, torsion. These systems typically rely on special fiber structures, such as Bragg gratings, polarization-maintaining fibers, among others.

On the other hand, the proposed system emphasizes simplicity, cost-effectiveness, and ease of implementation, providing a more practical approach for direct torsion measurement. In this system, the rotation of the state of polarization induced by fiber twisting is studied.

The experimental setup consists of a laser source, a polarization controller to define the input polarization state, a mechanical twisting stage, and a polarimeter connected to a computer, enabling real-time acquisition of the Stokes parameters and their visualization on the Poincaré sphere. The fiber used in our system was a standard SMF-28, incorporating a spliced capillary tube as cavity, which enhanced sensitivity to external perturbations.

The Stokes parameters were used to calculate the angles φ and χ, enabling a quantitative description of the polarization evolution. The experiment was performed by applying torsion to the fiber while maintaining fixed input polarization states: horizontal, 45°, and right-hand circular polarization.

For each configuration, the evolution of the state of polarization was monitored as a function of twist. A periodic modulation of polarization state was observed for all input configurations. The circular input polarization exhibited phase-wrapping discontinuities in φ.

In the future, we will study the sensor's response to other physical parameters.

ID: 125

Model-Based Systems Engineering for the Front-End of ANDES, the High-Resolution Spectrograph for the ESO Extremely Large Telescope

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The past decades have seen increasingly ambitious science goals in astronomical observations that have led to the construction of the first Extremely Large Telescopes, ground-based observatories larger than any currently in operation. Telescopes of this scale require highly advanced instrumentation, leading to unprecedented levels of complexity. Developing such instruments presents significant technical challenges that involve multiple disciplines and large international consortia. Managing these projects via traditional, document-based systems engineering often leads to miscommunication between teams, traceability gaps, and fragmented data. In response, the astronomical community is transitioning to a model-based systems engineering (MBSE) approach, replacing disparate documents with a centralized model of the system. This single source of truth allows for easier visualization, management and traceability across an instrument's various subsystems.

In this work, the AstroMBSE methodology, a specialized framework developed at Italy's Istituto Nazionale di Astrofisica (INAF) intended to standardize MBSE practices in astronomical instrumentation projects, is applied to the Front-End of ANDES, the high-resolution spectrograph for ESO's Extremely Large Telescope. Located at the Nasmyth focus of the telescope, the ANDES Front-End is a critical subsystem responsible for the collection and distribution of science and calibration light to the spectrograph's sub-units. Cameo Systems Modeler is utilized to develop a system architecture model that encapsulates the requirements, functional design, and physical implementation of the Front-End. Using this subsystem as a case study, it is demonstrated how the AstroMBSE methodology improves design clarity by allowing for the visualization of complex optomechanical systems through formal SysML diagrams, while ensuring coherence and traceability from high-level requirements down to physical components. By applying a state-of-the-art methodology to an in-development flagship instrument, this work highlights the potential of AstroMBSE as the standard for the management of the next generation of ground-based optical instrumentation for astronomy.

ID: 126

High-speed trace gas detection based on all-optical pattern matching using precise phase control of an optical frequency comb

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Gas-concentration measurement is essential not only in basic science but also in practical application fields such as environmental monitoring, industrial process monitoring, and breath analysis. Achieving a rapid measurement while maintaining sufficient sensitivity and enabling multi-species identification, remains challenging but highly demanding. In this work, we propose a method to directly convert gas concentration to an optical power with all-optical processing using an optical frequency comb. By employing broadband antiphase interference using a phase-controlled optical frequency comb, we generated a reference comb whose spectrum directly reflecting the absorption-line structure of the target gas of interest. Because the reference comb pulse contains only the target-gas absorption features, by sending this light to the sample to be measured, its transmitted power provides a direct measure of concentration of the sample without requiring spectrally resolved measurement or analysis, i.e., all-optical pattern matching.

We applied this technique to CH4 gas concentration detection at 1.6 μm wavelength region by use of a home-built Er: fiber comb. By precisely controlling the ratio of two frequency parameters of the comb, i.e., the repetition frequency (frep) and the carrier-envelope-offset frequency (fceo), the pulse-to-pulse phase of the comb pulses can be precisely adjusted, allowing the generation of precise and broadband antiphase pulses without relying on the precision of polarization optics as conventional methods. In this experiment, we measured the optical power of the comb pulse by detecting the RF power of the self-beat at the frep = 108 MHz using a photodetector. First, by changing the gas pressure in the sample cell step-by-step, we measured the IR power by the developed method and compared with a conventional pressure gauge. As a result, the detected RF power followed Lambert's law, confirming the validity of the proposed technique. Finally, by rapidly opening and closing the valve of the sample cell, we successfully monitored dynamic behavior by leveraging the direct optical power measurement capabilities of this method.

This technique performing all-optical pattern matching enables high-speed measurements at the repetition rate and allows for rapid identification of individual target substances even in mixed gases. It offers potential applications such as spatial gas-concentration imaging and monitoring chemical reactions.

ID: 127

Color Adjustment Potential in One-shade restorative materials: Thickness and Shade Interaction

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Abstract: One-shade composite resins (OCR) were recently introduced innovative biomaterials in restorative dentistry, engineered to simplify shade selection due to their color-matching ability. This study evaluates the Color Adjustment Potential (CAP_{00}) of 6 different commercially available OCRs across different substrate shades and restoration thicknesses.

Material and Methods: Cylindrical samples (15mm-diameter; 6mm-thickness) of conventional composite (Vitapan-Excell) with three different shades – dual samples (substrates A2, B2, C4; n=39) and six OCRs - single samples (n=3) were manufactured. Dual samples were further processed by preparing cavities (4mm-diameter) at 2mm and 4mm depth (n=3) and then restored with 6 OCRs: Omnichroma – O, Omnichroma Flow – OF (Tokuyama); Venus Pure Pearl One – V, Venus Pure Bulk Flow One – VF (Kulzer); Clearfil Majesty ES-2 – K, Clearfil Majesty ES Flow – KF (Kuraray). Reflectance of all samples was measured with a spectroradiometer and subsequently converted into CIE L*a*b* values (CIE D65; CIE 2o Standard Observer). CAP_{00} values were calculated for each OCR and substrate to test the chromatic adaptation capability of the materials.

Results: For 2mm thick restorations, the highest CAP_{00} was found for OF (0.61-0.84) and V (0.47-0.84), followed by O (0.60-0.78). Similar results were found for 4mm thick restorations: OF (0.71-0.84); V (0.50-0.68); O (0.43-0.69). The lowest CAP_{00} were registered for K and KF in all cases, with especially small values for the C4 substrate (0.12 and 0.17 for 2mm; 0.09 and 0.20 for 4mm, respectively).

Conclusion: Color adaptation of OCRs generally diminish with restoration thickness and darker substrates. Among materials studied, OF exhibited superior performance and was the most stable across thickness and shade, while V was more susceptible to thickness variations. These results highlight the importance of careful material selection and cavity design to optimize aesthetic outcomes in clinical practice.

Keywords: Colorimetry, dental materials, thickness, color adjustment potential

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ID: 128

Towards the miniaturization of cross-dispersed echelle spectrographs: Parametric modelling and trade-off analysis of three optical designs

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High-resolution (HR) spectroscopy plays a fundamental role in modern astronomy. Cross-dispersed echelle spectrographs (CDES) are at the forefront of HR spectroscopy for both ground- and space-based observatories. Currently, a wide range of science cases—from exoplanet detection to solar characterization—require the capabilities of HR CDES. One constraint with this design typology is that the instruments are very bulky and complex.

CDES come with a variety of optical designs, each tailored to specific scientific objectives and the observatory in which they are used. Based on their optical path, three major designs variations can be identified: the classic design, the double-pass, and the three-fold. The classic design is the original configuration; it was the first used in these instruments and remains the simplest to assemble. The double-pass design employs a single optical element as both the collimator and camera, enhancing the compactness of the system. Finally, the three-fold design—a white-pupil configuration that represents the current state of the art in ground-based observatories—uses a parabolic mirror to fold the beam three times. This approach enables a more compact design and allows for smaller aperture cross-dispersers and cameras, thanks to the white-pupil property.

Each of these designs contributes differently in terms of area footprint, spectral power, and efficiency. However, no systematic analysis has been done to quantify the contributions of these characteristics across the different configurations.

In this work, we propose a parametrization of the mathematical models for the three designs and propose a novel design configuration of CDES, the Cassegrain design. This approach allows us to quantify the impact of each design parameter on spectral power, area footprint, and efficiency and compare the three state of the art design with the Cassegrain. Ultimately, this parametrization enables a trade-off analysis between the designs using these criteria, helping to identify the optimal optical configuration for specific needs in terms of space, spectral power and efficiency to be applied in both space- and ground-based observatories.

ID: 129

Yb driven few-cycle, mJ-level 3 µm laser source

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Ultrafast mid-infrared lasers play a crucial role in science, as they provide access to molecular vibrational and rotational modes. The development of new-generation high-energy ultrafast sources has enabled significant advances in applications such as harmonic generation and attosecond pulse generation. One of the most well-established methods of producing mJ-level mid-infrared sources is Optical Parametric Chirped Pulse Amplification (OPCPA).

We present the current development stage of such a system driven by a high-repetition-rate Yb source. A fraction of our Yb driver seeds a commercial OPCPA enclosure, generating 65 µJ, 40 fs, 3 µm pulses with active CEP stabilization, which we scale to mJ level. To this end, the remaining output of the Yb driver is amplified in a home-built Chirped Pulse Amplification (CPA) system, serving as the pump for a custom 3 µm OPCPA system. This system was designed and numerically validated to amplify the 65 µm pulses up to 5 mJ with a duration of 85 fs pulses and a repetition rate of 10 Hz. Our approach allows the implementation of a pre-existing system in the laboratory, which operates 10 Hz. Nevertheless, operation > kHz would be feasible with thin-disk laser technologies.

We discuss the architecture of this system and the capabilities for driving next applications such as high harmonic generation, attosecond science, and particle acceleration.

ID: 130

Reaching the milli-arcseconds level in atmospheric dispersion correction for astronomical instruments.

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Astronomical observations performed using ground-based telescopes are inherently limited by atmospheric dispersion, which introduces wavelength-dependent positional shifts for any object observed away from the zenith. In high-resolution spectrographs, an Atmospheric Dispersion Corrector (ADC) is mandatory. With new diffraction limited instruments, aiming at using high-contrast, high-resolution spectroscopy techniques, the level of ADC residuals requirements is more demanding. In the case of RISTRETTO, a visible high-resolution spectrograph for the VLT, the ADC requirements are at the level of few milli-arcseconds, a threshold that traditional open-loop ADCs, relying solely on atmospheric models, struggle to achieve consistently due to local environmental fluctuations.

This work presents an active closed-loop control system for an ADC consisting of two counter-rotating plates, called Amici prisms. The system's innovation lies in its real-time metrology strategy: after passing through the prisms, the beam is split by a dichroic element. While the science band is transmitted to the spectrograph, the reflected light is directed to a sensing unit that monitors three distinct spectral spots (PSFs) simultaneously.

The control logic utilizes these three samples to decouple atmospheric effects from instrumental signatures, where a short-wavelength spot located in the high-dispersion blue regime serves as the primary feedback for prism rotation, a reference spot centered near the science band provides a zero-point baseline for alignment, and a long-wavelength spot is used to monitor and calibrate internal misalignments or optomechanical instabilities.

By implementing this multi-wavelength sensing approach, we demonstrate the ability to dynamically correct dispersion and suppress residuals to below the requirements, at the milli-arcsecond level.

ID: 131

Generalised Thomson scattering for relativistic plasma optics

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Spatiotemporally structured light - electromagnetic radiation with engineered couplings between its spatial and temporal degrees of freedom - has emerged as a powerful technique for controlling light-matter interactions. While traditional methods are effective at structuring weak electromagnetic fields, high-field physics requires structured light at the extremes of intensity and photon energy. Thomson scattering, for instance, can convert optical photons to x- or gamma ray photons, but typical configurations employ non-structured optical pulses and particle beams, offering little control over the generated radiation.

In this talk, we present a generalized Thomson scattering formalism that enables control over the spatiotemporal topology of high-energy photon emission. The formalism can be used to identify the optical pulse or electron bunch structure needed to produce a desired high-energy photon structure, providing an inverse design strategy for high frequency spatiotemporal tailoring.

We demonstrate the utility of this formalism by showing how an optical pulse with longitudinal orbital angular momentum can be converted to a high-energy spatiotemporal optical vortex. Moreover, we show how tailored relativistic particle beams can function as optical elements - analogous to curved mirrors or gratings - to format the phase and intensity profile of up-converted radiation. These results were obtained with the particle-in-cell code OSIRIS [1] coupled with the radiation diagnostic tool RaDiO [2]. This work establishes a proof of principle for a new generation of high-energy photon sources with custom spatiotemporal structure.

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ID: 132

Fabrication and structural characterization of dexamethasone-loaded SZ2080 structures via two-photon polymerization

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Two-photon polymerization (2PP) has appeared as a promising fabrication technology for the development of high-resolution three-dimensional microstructures, offering feature sizes down to the sub-micrometric scale. Due to its exceptional spatial resolution and the availability of biocompatible materials, 2PP is uniquely suited for the creation of sophisticated drug delivery systems and tissue engineering scaffolds. Among these materials, the hybrid organic-inorganic sol-gel resin SZ2080 stands out for its high mechanical stability and minimal shrinkage during processing, as well as its biocompatibility. This study presents the design, fabrication, and structural characterization of passive drug-eluting structures using SZ2080 doped with Dexamethasone, a corticosteroid used for its anti-inflammatory and regenerative properties.

The experimental approach involved the homogeneous incorporation of Dexamethasone into the liquid photoresist at varying concentrations prior to the 2PP process. These devices were printed with varying morphologies by adjusting key printing parameters, such as slicing and hatching distance. The primary objective was to evaluate the viability of loading a small-molecule drug into the matrix without compromising the polymerization process or the structural integrity of the scaffolds. To assess the impact of drug loading and printing parameters on the final architecture, the fabricated structures, both prior and post processing, were compared using advanced optical and electron microscopy techniques.

This work provides a solid starting point for developing customized, biocompatible drug delivery devices and further explores whether drugs can be successfully incorporated before photopolymerization. It shows that by adjusting parameters such as hatching distance, slicing distance, and pore size, it is possible to fabricate functional medical microdevices with well-defined structural features. This also makes it possible to tune the drug release profile through precise control of the device's geometry.

ID: 133

Dimensionality reduction in hyperspectral profiles classification of cells from serous cavities

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Hyperspectral imaging enables acquisition of high resolution spectral information over a broad wavelength range, capturing detailed signatures of light–matter interactions in biological samples. In this study, hyperspectral images (HYSIs) of stained and unstained cells from serous cavity fluids were acquired, providing pixel level spectral profiles that encode both structural and compositional information. Given the clinical relevance of serous effusion cytology in the diagnosis and management of advanced malignancies, the development of rapid and automated analysis methods presents considerable interest.

However, hyperspectral profiles (HYSPs) generate high dimensional datasets that pose challenges related to computational cost, redundancy, and model generalization. Efficient dimensionality reduction is essential to preserve discriminative information while enabling robust and scalable analysis. To address this, we propose a hybrid scenery combining machine learning applied on HYSPs with deep learning applied to HYSIs for pixel-wise segmentation.

A database was built by collecting HYSPs associated with cellular components (nucleus and cytoplasm) and image background. Three machine learning frameworks (AutoGluon, H2O and Auto-Sklearn) were applied for HYSPs classification, followed by permutation feature importance (PFI) to identify the ten most informative spectral bands. Comparisons between permutation types was presented in terms of classification accuracy. The second input database was built from HYSIs with reduced sets of spectral bands and subsequently used for their classification based on YOLOv26 neural network enabling pixel-wise segmentation on images.

Performance was evaluated using precision, recall and the IoU (Intersection over Union) or mAP (Mean Average Precision) for both stained and unstained samples, comparing with ground truth annotations provided by expert pathologists.

The results demonstrate that integrating hyperspectral imaging with dimensionality reduction and automated analysis can significantly improve diagnostic accuracy, reduce processing time, and enhance reproducibility, supporting the development of non-invasive tools for clinical cytology.

Keywords: Hyperspectral imaging, cytology

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ID: 134

A Single-Stage Approach to Dynamic Focusing for High-NA Full-Field OCT

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The loss of focus in depth is a limiting factor in the achievable lateral resolution and axial range in optical coherence tomography (OCT). This effect is particularly apparent when employing high numerical aperture (NA) objectives, that have a narrow depth of focus (DOF).

The further the coherence gate lies outside of the DOF, the more the focus of the OCT image degrades, accompanied by a loss of achievable axial range if this is not compensated for.

Time-domain OCT (TD-OCT) is compatible with dynamic focusing methods, as signal is only acquired for a single depth at a time. These methods can synchronise the positions of the focus and of the coherence gate as the sample is scanned axially, maintaining focus and coherence gate alignment throughout the axial range. However, these methods usually involve the use of two mechanical elements that must be synchronised, adding complexity to the interferometer. Although spectral-domain OCT (SD-OCT) methods have an advantage in imaging speed and sensitivity over TD-OCT, SD-OCT interrogates all depths simultaneously and is therefore incompatible with dynamic focusing methods.

In this work, we present a simplified dynamic focusing approach that employs a single mechanical element (a translation stage) adapted to a full-field configuration. Validated through theoretical modelling and experimental approaches using a high NA objective (NA=0.5), this method successfully maintains focus and coherence gate alignment over sample depths up to 4 mm. Through en-face and cross-sectional imaging, it was confirmed that the lateral resolution in the OCT image is preserved along the axial range. The system achieves comparable functionality to dynamic focus methods employing two mechanical elements, but with significantly reduced mechanical complexity and the added advantage of not requiring prior knowledge of the sample's refractive index to synchronise the focus and the coherence gates.

The simplified method presented operates around an ideal sample refractive index of 1.41, where the path length change is doubled in the sample arm as the objective is scanned towards the sample, while the reference arm remains static. Performance of the system does degrade at deviations from this refractive index by a varying amount depending on DOF of the objective. However, a wide variety of biological tissues exhibit an index of refraction close to 1.41, making the approach highly useful for biomedical imaging applications.

ID: 135

Acute Kidney Injury/Chronic Kidney Disease diagnosis through Optoelectronic-based urine analysis

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Acute Kidney Injury (AKI) is a sudden, often reversible loss of kidney function that increases the risk of mortality and progression to chronic kidney disease (CKD). Current diagnostic methods based on serum creatinine (SCr) are limited, as SCr may remain normal in early stages. This study evaluates non-invasive optoelectronic techniques, fluorescence and Raman spectroscopy, to detect urinary biomarkers associated with AKI and CKD, aiming to improve early diagnosis.

Urine samples were collected from volunteers in the LUMINA project and from nephrology patients with informed consent. The cohort included healthy individuals (n=7), CKD patients (n=6), and AKI patients (n=2). Standard creatinine solutions (1.25–100 mg/dL) were prepared as references. Fluorescence measurements were performed using a Jasco FP-8300 spectrofluorometer with quartz cuvettes. Three-dimensional spectra were acquired by varying excitation and emission wavelengths. Raman spectra were obtained with a 532 nm laser spectrometer at ISEL. Analysis focused on identifying spectral differences between groups.

Fluorescence spectroscopy distinguished creatinine concentrations and revealed differences between healthy and diseased samples. AKI and CKD urine showed increased fluorescence in regions linked to aromatic amino acids and protein metabolites, especially tryptophan, suggesting biomarker accumulation. Raman spectroscopy showed low sensitivity to creatinine due to noise and weak scattering. However, some CKD samples displayed peaks consistent with calcium oxalate (400–600 cm−1). Increasing laser power (5–80 mW) improved signal quality and revealed consistent patterns.

In general, fluorescence spectroscopy shows strong potential as a rapid, non-invasive diagnostic tool. Raman spectroscopy, though currently limited, may gain value with optimization. Together, these methods offer a complementary approach for earlier detection of kidney disease.

In parallel, artificial intelligence algorithms in Python are being developed for preprocessing and automated spectral analysis. These tools support feature extraction and pattern recognition, reducing operator dependency and improving scalability and reproducibility in spectroscopic diagnostics.

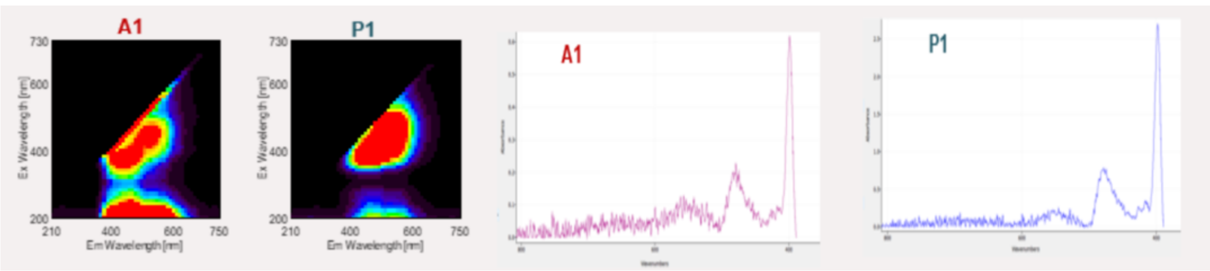

Figure - Left: Fluorescence spectra obtained from samples from donors with CKD (A1) and healthy donors (P1). Right: Raman spectra obtained from samples from donors with CKD (A1) and healthy donors (P1).

ID: 136

Fiber Bragg Grating Biaxial Displacement Sensors for Long-Term Monitoring of Wooden Panel Paintings

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This study reports the development, fabrication, and characterization of novel fiber Bragg grating (FBG)-based biaxial displacement sensors capable of simultaneously measuring longitudinal and transversal displacements. The sensing approach relies on the integration of two FBGs whose combined response enables accurate biaxial measurements. The proposed devices offer several advantages, including design simplicity, ease of fabrication and installation, and low intrusiveness. In particular, the ability to adjust the distance between fiber holders during fabrication allows tailoring of both sensitivity and operational range to specific application requirements. These features make the sensors a cost-effective, reliable, and safe solution for several applications, including structural health monitoring (SHM) and structural monitoring of artworks, especially in contexts where minimal intervention is required. To demonstrate their applicability, two sensors were deployed in a real-case scenario involving a 16th-century wooden panel painting (WPP), São Pedro, exhibited at the Grão Vasco National Museum (Viseu, Portugal), where they were installed at critical locations to monitor relative displacements between wooden boards. The main objective of these devices is to assess structural movements and evaluate the influence of environmental conditions on the WPP through continuous, long-term, high-resolution measurements across seasonal temperature and relative humidity cycles. The collected data provide valuable insights for preventive conservation, supporting informed decision-making and targeted technical interventions aimed at preserving the integrity of the painting. Furthermore, the results contribute to the calibration of numerical models and to the dissemination of knowledge applicable to similar historical and cultural assets. Initial monitoring results obtained during the first months after installation are presented and discussed, highlighting the sensor performance and the relevance of the measured displacement data for heritage conservation.

ID: 137

YOLO Based Method for Defect Detection in Painted Surfaces

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Surface quality control of painted exteriors of equipment is essential, since purchasing decisions are often influenced by the appearance of the product. Over time several developments have a focus on automating this process for integration into the manufacturing process, reducing potential human mistakes and improving efficiency. Image processing and analysis are the key technologies for automatic inspection methods. Due to variability in a production line, such as lighting conditions, temperature and movement, inspection methods based on traditional image processing techniques can be difficult to implement, intrusive to existing infrastructure, and less robust. In this context, deep learning has demonstrated effective performance in defect detection and classification. In this work, we propose a defect detection method for the painted surfaces of water heater covers, using a YOLO based segmentation model image processing. The model is focused on the detection of two types of surface defects, craters and scratches, which are the two most common and visible defects in painted surfaces.

A YOLOv11 instance segmentation model was developed and trained with 139 images from 23 water heater cover samples. Due to the specular nature of the painted surfaces, the images were acquired using an image-acquisition system with dark-field illumination, that highlights the defects by minimizing specular reflections. This system considers the constraints of the production line, such as limited space and constant movement of the surfaces. After optimization the model was able to detect craters and scratches and generate a pixel level masks corresponding to the defect locations. For crater defects, the model achieves a precision of 78.6% and recall of 78.9%, with an mAP50 of 81.8% for the bounding box and 52.8% for the defect segmentation mask. Scratch detection achieved lower performance, with a precision at 75.5% and recall at 69.4% and mAP50 metrics of 73.6% and 57.9% for box and mask, respectively. Although, the mAP50 metrics reflect limited segmentation robustness, the achieved classification performance is satisfactory, particularly in terms of recall, which is prioritized in order to minimize undetected defects. The system also proved computationally efficient, with an average image processing and decision time of 7s per surface image.

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ID: 138

Logistic Regression-Based Method for Defect Detection in Painted Surfaces

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The initial perception of a device can significantly impact the purchasing decision, underscoring the significance of quality control of the device's exterior surfaces, particularly painted finishes. However, inspection processes in industry often rely on subjective human inspection, which can introduce variability and errors. Automating this process can reduce the resource consumption and improve consistency.

This work proposes an automatic defect detection system for painted surfaces of water heater covers, integrating of an image acquisition system and a defect-detection model. The image acquisition system is based on dark field illumination which increases defects contrast in the image by minimizing specular reflections. In this design, the camera is positioned perpendicular to the surface, and a grazing light source is placed at a low angle of incidence. To ensure complete visualization of the surface in analysis, two images are captured per surface, one for each illumination side. The image acquisition system includes a 12.4 MP machine vision camera (IDS, model 20M11-C0828 8mm) equipped with a lens with focal distance of 8 mm, and three 1-meter-long LED stripes on each side, each with a luminous flux of 7800 lm.

This study centered on the binary classification of water heater covers either as defective or non-defective based on the presence of craters defects. The proposed approach combines template matching method and logistic regression-based algorithm to classify the surfaces. Template matching uses a sliding window approach in which a template (the defect image) is scanned across the input image (acquired surface image) and a similarity measure is calculated to detect the most similar region. The maximum value obtained from this process is used as a predictor for the logistic regression model, and classification (defect or not) is performed by applying a decision threshold of 0.5 to the model output.

After successful training, the model was evaluated on 23 different samples. Results demonstrate a robust model performance, achieving an accuracy of 95.6 %, a precision of 90.0 %, a recall of 100%. All defect instances were correctly identified and only one non-defective surface was incorrectly labeled as positive. These results support the effectiveness of the proposed method for water heater covers surface inspection.

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ID: 140

Optical fibre sensor for water contaminant detection - PFAS case study detection

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Per and polyfluoroalkyl substances (PFAS), commonly known as "forever chemicals" [1], are synthetic compounds, toxic, persistent and bioaccumulative [2] and can be found in almost all environmental matrices, including water sources and aquatic ecosystems [2].

The conventional analytical methods for the detection of PFAS include liquid-chromatography and gas-chromatography – mass spectrometry. These techniques typically require off-site analysis, are time consuming and expensive for in-field routine environmental monitoring [2].

Sensors based approaches offer the potential for fast, on-site detection [3]. The sensor proposed in this work is based on optical fibres having advantages, not only due to the fibre characteristics such as light weight and small size [4] but also due to its simple structure and fabrication. Being so, an optical sensor based on a multimode optical fibre interferometer is presented in this work, with a selective layer for PFAS detection with potential use for aquatic ecosystems.

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ID: 141

Reconfigurable Optical Switching using Sb2Se3 Phase-Change Material

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The rapid growth of large-scale data center operations is driving increasingly demanding requirements for data center interconnects, where bandwidth, scalability, and energy efficiency are critical constraints. Optical switching has emerged as a key technology to address these challenges, enabling high-capacity and reconfigurable data movement in photonic integrated circuits. In this context, scalable and energy-efficient switching architectures are essential to support the rising complexity of modern computing systems.

Interferometric switching fabrics based on cascaded Mach–Zehnder interferometers rely on precise phase control to ensure correct routing and low crosstalk across multiple stages. Achieving this level of control in large-scale circuits remains challenging, while conventional phase tuning mechanisms, such as thermo-optic or carrier-based approaches, require continuous power consumption and increase system complexity.

In this talk, phase-change materials are introduced as a platform for non-volatile and reversible refractive index modulation in photonic circuits. In particular, low-loss chalcogenides such as Sb2Se3 allow efficient phase tuning with negligible optical absorption, supporting compact implementations and eliminating static power consumption. Their integration in interferometric structures enables both reconfigurable switching and post-fabrication calibration of complex networks.

The resulting approach combines non-volatile phase control with scalable switching architectures, enabling programmable photonic systems with improved robustness and reduced operational power consumption. These capabilities highlight the potential of phase-change-material-based photonics for next-generation optical interconnects requiring efficient, reconfigurable, and large-scale operation.

ID: 142

Classical Emulation of the BB84 Quantum Key Distribution Protocol over Optical Fibers

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Quantum Key Distribution (QKD) is one of the most relevant applications of quantum mechanics for secure communications. Among the existing QKD schemes, the BB84 protocol, proposed by Bennett and Brassard, enables two users, traditionally referred to as Alice and Bob, to establish a shared cryptographic key through the transmission of quantum states of light. Its security relies on the fundamental principle that any eavesdropping attempt inevitably disturbs the transmitted states, introducing detectable errors in the received signal.

In this work, we present a classical experimental framework for the implementation of the BB84 protocol over optical fiber. The system uses a continuous tunable laser source operating at 1550 nm, collimated and polarized before being coupled into a standard SMF-28 single-mode fiber. Half-wave plates are used to emulate the basis choices of Alice and Bob, while a polarizing beam splitter separates the optical signal into the logical bit states BIT 0 and BIT 1. The transmitted signals are detected using avalanche photodetectors.

A 20-bit sequence was successfully transmitted between Alice and Bob. After basis reconciliation, a final 12-bit key, 100111001010, was obtained, confirming the expected behavior of the BB84 protocol, in which only the bits measured with matching bases are retained and the remaining bits are discarded during the sifting process.

Building on these results, future work will incorporate an eavesdropping scenario based on an intercept-resend strategy, enabling a direct experimental assessment of the protocol's sensitivity to signal interception through the analysis of the induced quantum bit error rate (QBER). Further experiments will also evaluate the protocol performance over different optical fiber platforms beyond standard SMF-28, considering parameters such as attenuation, polarization stability, and key retention efficiency.

ID: 143

Exploring New Frontiers in Optical Interferometric Sensing: Vernier effect and White Light Interferometry for Harsh Environments

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The growing demand for monitoring extreme environments has driven the advancement of optical sensing systems due to their high sensitivity and immunity to interference. In this context, interferometric sensing stands out as an effective solution for precise measurements of physical parameters. This paper will focus on explaining interferometric sensors and the techniques used to interrogate them, with particular emphasis on spectral analysis, the Vernier effect, and the White Light Interferometry (WLI) technique.

Typically, interferometric cavities are studied in terms of their spectrum, which is characterised by fringes. Their use as sensors stems from monitoring the wavelengths at which the extremes of the spectrum occur. It is important to note that the sensitivity exhibited by these sensors increases as their length decreases. However, the fabrication of short cavities presents certain difficulties, and the Vernier effect emerged as a solution. The envelope of this effect, one of the most studied waves, exhibits characteristics similar to those of a small-sized cavity and allows for the implementation of giant sensitivities. The combination of the Vernier effect with the Push-Pull technique has demonstrated the ability to achieve colossal sensitivity, as this technique allows the exploration of spectral extremes close to the balanced state. Although the Vernier effect emerged in this century, the WLI technique can be described as the integral of the spectral density of the Vernier effect. This technique allows a faster temporal analysis of the interferometric cavity length compared to the spectral analysis obtained by an optical spectrum analyser (OSA) or a spectrometer.

This work will focus on the connection between different areas of fibre-optic interferometric sensors. A brief introduction to what an interferometer is and how it functions as a sensor will enable it to present the Vernier effect and the mathematical model that distinguishes applications where this effect exhibits sensitivity amplification from those where no amplification occurs. Furthermore, application examples will be presented that not only validate the theoretical model but also demonstrate the giant sensitivity that the Vernier effect can achieve. Finally, a presentation of the WLI technique will be given, showcasing several interrogators as well as a real-time processing algorithm that not only reduces noise but also compensates for the interrogator's non-linearities.

ID: 144

Adaptive Lighting Control System for Automotive Headlights Based on Computer Vision

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Nighttime driving safety depends on automotive lighting systems as the primary mechanism for perceiving the surrounding environment. Fixed high-beam systems cause glare for nearby drivers, with visual recovery times between 1.5 and 5 seconds which, at 90 km/h, are equivalent to up to 125 meters of blind travel, paradoxically turning the protective system into a risk for other road users. In response to this limitation, solutions have been proposed in which the beam pattern is dynamically modified to suppress glare affecting surrounding drivers; however, these systems have been conceived predominantly for open-road scenarios and lack the integration between artificial vision and embedded control required to operate with consistent technical precision in complex road environments.

This work presents the design and functional evaluation through simulation of an Adaptive Driving Beam (ADB) system that integrates a single-stage object-detection algorithm, based on convolutional neural networks, with an LED-matrix electronic control subsystem managed by an open-architecture microcontroller. The single-stage architecture responds to a dynamic-processing imperative: two-stage models introduce latencies of 80–150 ms per frame, which are incompatible with the vehicle update rate required for light-pattern transitions to remain subthreshold and imperceptible to the driver.

The evaluation shows a detection rate of 97% with mAP50 close to 1.0. The remaining 3% corresponds mainly to false negatives under image degradation, whose safety implications are analyzed as a function of the geometry of the roadway encounter. The electrical characterization confirms R2=1.00 with a resistance of 12 Ω, ensuring continuous luminance transitions consistent with the sensitivity of the human visual system to the temporal derivative of luminance. The optical range of 250 meters provides a time margin of 2.64 seconds before the critical glare zone defined by UN/ECE Regulation No. 149, exceeding regulatory requirements.

By demonstrating coherence between the neural perception layer and photonic actuation, this work establishes a methodological basis for vehicular lighting systems that operate as active road-safety agents in mixed-traffic environments, contributing to the advancement of safer and more intelligent autonomous-mobility technologies.

ID: 145

Visible Light Communication System Integrated with SUMO Simulation

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This work explores the integration of Vehicular Visible Light Communication (V-VLC) with urban traffic management systems as a complementary technology to conventional Radio Frequency (RF) communications in Intelligent Transportation Systems (ITS). VLC exploits the unlicensed visible light spectrum and existing LED-based infrastructure, including vehicle headlights, traffic signals, and street lighting, to enable high-directionality, low-interference communication in dense traffic environments.

The proposed system supports multiple communication paradigms, including Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Infrastructure-to-Vehicle (I2V), and Lamp-to-Vehicle (L2V). It is implemented using RGBV LEDs as transmitters and PIN photodetectors as receivers, employing On-Off Keying (OOK) modulation. Data exchange is structured through a 64-bit frame protocol designed for vehicular applications.

To simulate a realistic V2X (Vehicle-to-Everything) environment, traffic scenarios are modeled using SUMO (Simulation of Urban MObility), which generates dynamic vehicular data including position, speed, queue length, and waiting time. These simulation-derived data frames are then encoded and transmitted through the VLC physical layer, where the optical transmission and reception performance is evaluated using RGBV LED transmitters and PIN photodetector receivers.

The results demonstrate the feasibility of integrating VLC with traffic simulation environments for enhanced urban monitoring and communication. The proposed approach highlights the potential of VLC-based vehicular networks to improve traffic awareness and management, particularly in high-density scenarios, while complementing existing RF-based systems in future smart transportation infrastructures.

ID: 146

Laser-processed WO3/graphene oxide nanocomposites for Raman-active fiber Fabry–Perot hydrogen sensing

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This work develops a laser-assisted route for integrating WO3/graphene oxide-like nanocomposites into fiber-tip Fabry–Perot cavities as Raman-active optical transducer layers for hydrogen sensing. The approach combines nanoparticle generation, polymer-to-carbon conversion, controlled oxidation, and cavity-based optical interrogation in a single microscale platform. Tungsten nanoparticles were first produced from bulk W by femtosecond laser processing under ambient conditions, yielding low-oxidation metallic W nanoparticles. These particles were dispersed in a polyimide matrix and introduced into a femtosecond-laser-fabricated Fabry–Perot cavity at the optical fiber tip. After drying, localized picosecond UV irradiation converted the polyimide into laser-induced graphene, producing a conductive carbon scaffold with embedded W nanoparticles. Subsequent oxygen plasma activation and thermal oxidation at 300 °C were used to transform the exposed W/LIG interface into a WO3/GO-like hybrid layer while preserving optical access to the active material.

Hydrogen sensing was addressed through Raman tracking of the WO3 vibrational response rather than only through electrical resistance or broadband optical attenuation. The spectral analysis focused on the relative evolution of W–O stretching modes and O–W–O bending modes, which are sensitive to local coordination, defect density, and redox-induced lattice distortion. Upon H2 exposure, the WO3/GO layer showed a decrease in bending-mode intensity and an increase in stretching-mode intensity, suggesting hydrogen-induced modification of the WO3 matrix and redistribution of the local W–O bonding environment. This interpretation is consistent with spectro-electrochemical WO3 studies showing that proton or ion insertion produces transmission changes and stepwise tungsten reduction, with strong optical coloration associated primarily with W4+ formation rather than only W5+. In this context, the Raman response is treated as a structurally resolved optical marker of hydrogen-driven WO3−x formation and reversible tungsten redox chemistry. Here, the Fabry–Perot cavity is used as a confined fiber-tip optical platform for co-localizing the active WO3/GO layer with Raman interrogation. This architecture provides a basis for future optimization of cavity geometry, oxide crystallinity, graphene oxidation state, catalytic activation, and Raman peak-ratio metrics for selective H2 sensing.

ID: 147

High-Speed Lithium Niobate Polarization Control for Polarization-Encoded QKD

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Quantum key distribution (QKD) has emerged as a promising approach for secure communication in the context of emerging threats to classical cryptography posed by quantum computing. In polarization-encoded implementations, information is carried in the state of polarization of single photons, requiring accurate and repeatable state generation. However, practical systems must also cope with polarization drift and other possible misalignments in the transmission channel while maintaining high modulation rates [1], imposing constraints on the choice of encoding hardware. State-of-the-art implementations typically rely on high-speed interferometric phase-modulation schemes for basis generation, combined with polarization control techniques for channel compensation, which are typically limited to modulation rates in the range of hundreds of kHz to approximately 1 MHz, such as piezoelectric fiber squeezers [2].

In this work, we present a lithium niobate-based electro-optic polarization controller (EPC) enabling high-speed polarization state preparation. The device consists of multiple electro-optic stages (6–8), each acting as a fully customizable, voltage-controlled waveplate, allowing arbitrary state of polarization generation without requiring a predefined input state [3]. Compared to conventional polarization controllers, the proposed approach offers sub-100 ns response times, enabling operation in the tens of MHz range. This flexibility further enables its use for channel compensation, where part of the available waveplate stages are used for polarization drift compensation in the quantum channel, reducing the need for external polarization control equipment typically required in interferometric phase-modulation-based setups.

We demonstrate stable orthogonal polarization state modulation at 21.5 Msps, achieving consistent state preparation across all bases with polarization leakage below 0.5%. Additionally, we present a calibration methodology for this device, addressing the non-uniqueness of voltage configurations in multi-stage systems with fully customizable waveplates.

These results demonstrate a high-speed and flexible alternative to conventional polarization encoding approaches, enabling both state preparation and channel compensation within a single device.

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ID: 149

High Transmission in Step-Index Multimode Fibre Tapers

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This work presents a systematic characterisation of step-index multimode fibre tapers in terms of transmission efficiency and output mode profile under controlled excitation conditions. Tapers with ratios from 2.5:1 to 10:1 were fabricated using a GPX3600 Vytran system and characterised at a wavelength of 635 nm.

In contrast to earlier observations that step-index tapered fibres exhibit high loss (i.e., < 20% transmission), our results demonstrate that transmission ranges from 50 to 80% when the effective input numerical aperture is carefully controlled. By scanning the input numerical aperture over the range 0.01–0.08, we observe that optical power can be preserved even in strongly tapered geometries under optimised coupling conditions.

Partially adiabatic mode evolution in tapers is indicated by the dependence on modal excitation as the reduced transmission with higher-order mode coupling conditions. In addition, we report the mode size of the step-index tapers compared to the graded-index tapers, and find that the graded-index tapers still offer a smaller mode size and relatively high transmission. This provides insight into the design of tapered fibre for application in high-resolution fibre-fed spectrographs, where optimisation of throughput and mode size is critical.

ID: 150

Advances in diode-pumped metastable rare gas lasers

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Novel high-energy diode pumped gas lasers, which integrate atmospheric-pressure discharge with high-power diode laser pumping, combine the advantages of gas flow cooling and highly efficient optical pumping, representing a key developmental direction for future high-energy laser systems. However, a critical bottleneck lies in the efficient generation of atmospheric-pressure gain media: in highly collisional environments, gas discharges are prone to uncontrolled glow-to-arc transitions, making it extremely challenging to stably achieve high densities of metastable species.

This presentation highlights recent progress in breaking away from the traditional “arc-suppression” paradigm by actively harnessing arc plasma for efficient laser operation. Specifically, we propose a novel laser architecture based on axial nanosecond pulsed discharges that, under high-repetition-rate excitation, synergistically achieves high metastable density, extended gain length, and precisely controlled gas temperature. Experimental results successfully demonstrate efficient laser oscillation under this mechanism, confirming the feasibility of arc-state plasma as a high-quality, large-volume gain medium. Furthermore, we report the discovery of an optoelectronic coupling effect between the intense resonant pump optical field and the discharge channel. This phenomenon offers a promising pathway to mitigate the spatial randomness inherent in high-pressure discharges, enable active control of atmospheric-pressure plasmas, and establish a fundamentally new technical route for the efficient preparation of gain media in next-generation high-energy semiconductor-pumped gas lasers.

ID: 152

Study on the amplification of diode pumped alkali vapor laser

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Diode-pumped alkali vapor lasers (DPALs) integrate the efficient flow-cooling of gas lasers with the compact, all-electric architecture of solid-state systems, offering exceptional quantum efficiency and favorable size-weight-power (SWaP) characteristics. While traditional oscillator configurations struggle with the power–beam-quality trade-off at medium scales, amplifier architectures (DPAA) present a critical pathway to simultaneously achieve high output power and high spatio-temporal coherence, thereby expanding DPAL applications from pure energy delivery to precision metrology and coherent communications. However, practical DPAA development is hindered by severe thermal deposition effects that distort wavefronts and degrade beam quality, alongside a lack of accurate predictive models and optimized system architectures.

To address these challenges, this study establishes a comprehensive three-dimensional multi-physics coupled model integrating heat transfer, fluid dynamics, wave optics, and laser kinetics, which quantitatively elucidates the thermal-to-optical degradation mechanism. Guided by this framework, we constructed static and flowing vapor-cell experimental platforms, achieving 40 W and 120 W high-beam-quality outputs, respectively. Furthermore, we systematically evaluated pumping configurations and amplification schemes, demonstrating the thermal-management superiority of forward pumping and proposing an optimized 2–3 pass pre-amplifier combined with a single main stage for kilowatt-scale operation. We also explored high-repetition-rate pulsed-seed amplification under continuous pumping, revealing a viable route to significantly enhanced peak power. This work provides a robust theoretical and experimental foundation for next-generation high-power, high-coherence DPAL systems, accelerating their transition toward practical energy-information applications.

ID: 153

Real-time temperature monitoring in a diode-pumped alkali laser via NIR methane absorption spectroscopy

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Diode-pumped alkali lasers (DPALs) represent a critical pathway for next-generation high-energy, electric-driven laser systems. However, their output performance and operational safety are fundamentally constrained by thermal deposition in the vapor cell, which induces refractive index gradients, beam quality degradation, and power roll-over. Conventional non-intrusive temperature diagnostics face significant limitations, including susceptibility to environmental disturbances, reliance on tracer atoms, or insufficient temporal resolution for dynamic thermal processes. While direct absorption spectroscopy (DAS) offers a high-speed alternative, its practical implementation in DPALs is often compromised by optical interference and baseline distortion in compact cell geometries.

To address these challenges, we developed a robust, compact near-infrared (NIR) methane sensor based on frequency-scanned DAS for spatiotemporally resolved temperature rise measurement. By employing two time-division-multiplexed DFB lasers (1650.9 nm and 1653.7 nm) coupled with an InGaAs photodiode array, we achieve quasi-2D thermal mapping. A novel one-step iterative fitting algorithm is introduced to simultaneously extract baseline parameters and gas temperature, effectively mitigating etaloning-induced spectral distortion. This diagnostic approach enables real-time, non-intrusive thermal monitoring without complex hardware or computational overhead, providing a scalable and reliable tool for optimizing thermal management and advancing high-power DPAL/DPAA systems.

ID: 154

The Impact of Ambient Gas Conditions and Delay Time on Emission Characteristics of Al Plasma Generated using Nanosecond Laser-Induced Breakdown Spectroscopy (nsLIBS)

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This paper employs nanosecond laser-induced breakdown spectroscopy (ns-LIBS) to investigate the emission enhancement of aluminum (Al) targets under various gases including helium (He), argon (Ar), and air. A Q-switched Nd: YAG laser emitting at 1064 nm with 5 ns of pulse duration was utilized to generate the Al plasma. The measured results reveal that the intensity enhancement factor exhibits to be low in the air, however, a significant increase is noticed in the presence of Ar and He gas environment. Furthermore, the influence of time delay ranges from 100 to 1500 ns, on the intensity of emission lines, and the plasma parameters (electron temperature and electron number density) of laser-induced Al plasma were determined in the presence of air, He, and Ar. The plasma electron temperature and electron number density were measured using the Boltzmann plot and Stark broadening line profile method,respectively. It was found that the plasma parameters were much higher with Ar gas relative to air and He. This study suggests that the LIBS in combination with gases yields signal enhancement which could significantly improve the performance of LIBS for various applications, including materials science, environmental monitoring, forensic analysis, and industrial quality control.

ID: 156

In Vitro Time-Correlated Near-Infrared Photon Counting for Direct Detection of Singlet Oxygen in 5-ALA-Sensitized Glioblastoma Cells

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Glioblastoma (GB) exhibits pronounced therapeutic resistance, motivating mechanistic investigations of photodynamic therapy (PDT)-induced cytotoxicity. PDT is predominantly mediated by reactive oxygen species and singlet oxygen (1O2); however, direct spectroscopic detection of 1O2 in biological environments remains challenging due to its microsecond lifetime, weak phosphorescence intensity, and significant background luminescence.

Here, we report direct detection of 1O2 phosphorescence using a time-correlated multiple-photon counting system in the near-infrared (TCMPC-NIR). The custom-built setup employs a NIR-sensitive detector combined with narrowband interference filters at 1200, 1270, and 1340 nm, enabling spectrally selective identification of the 1O2 emission at 1270 nm following 635 nm excitation of 5-ALA-induced PPIX.

Measurements were performed *in vitro* using LN-229 glioblastoma cells treated with 5-aminolevulinic acid (5-ALA) to induce endogenous accumulation of protoporphyrin IX. Upon irradiation with 635 nm, a reproducible emission signal at 1270 nm was detected and temporally resolved over a five-minute illumination period. Signals at 1200 nm and 1340 nm remained at baseline levels, confirming the high spectral specificity of 1O2-phosphorescence emission at 1270 nm and the detection set-up used. Independent validation of 1O2 generation was obtained using fluorescence-based Singlet Oxygen Sensor Green assay.

Post-irradiation viability assays revealed up to a 50% reduction in cell viability under PDT conditions. Time-resolved measurements demonstrated a mild but reproducible temporal evolution of the 1270 nm signal, indicating dynamic modulation of 1O2 production during irradiation. These findings demonstrate direct, spectrally selective detection of singlet oxygen in 5-ALA–sensitized glioblastoma cells and establish a quantitative link between 1O2 generation dynamics and PDT-induced cytotoxicity.

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ID: 157

Integrated Sensing and Communications: Coexistence of a 400G Coherent Link and Raman-based Distributed Temperature Sensing at 1064 nm

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The Integration of Sensing and Communication (ISAC) in optical fiber networks has attracted significant interest, since it optimizes resources by doubling the functions of the fiber infrastructure. By integrating Distributed Fiber Sensors (DFSs), optical fiber links can operate as a continuous, long range sensing system, allowing real time environmental monitoring across the network. DFSs have been widely investigated for several applications, including monitoring infrastructure health, pipelines and submarine cables, or fire/temperature detection, among others. Regarding temperature monitoring, Raman-based Optical Time Domain Reflectometry (OTDR) systems are the most common technology, since it relies on the direct detection of the Raman bands power ratio, providing a response that is only temperature dependent [1].

This work demonstrates the coexistence of a Raman-based Distributed Temperature Sensor (DTS) [2] with a 400 Gb/s dual-polarization (DP)-16QAM coherent transmission system. The DTS system uses a 1064 nm pump source to minimize interference between sensing and transmission signals. A 1000 m standard single-mode fiber was used, with a 160 m section subjected to controlled temperature variations. While the temperature was monitored by the DTS, the transmission signal was launched into the fiber, and the corresponding bit-error-ratio (BER) was evaluated.

The proposed DTS demonstrates accurate temperature monitoring, with a temperature and spatial resolution of 20 °C and 33 m, respectively. With the DTS in operation, the transmission signal exhibits a stable BER, showing no degradation under temperature variations. Also, the BER remains at least two orders of magnitude below the standardized Optical Internetworking Forum (OIF) limit. These results demonstrate the coexistent of DTS and transmission signals with crosstalk free operation, thus validating the feasibility of Raman based DTS-ISAC architectures using existing telecom infrastructure.

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ID: 158

Intensity scaling of rotational anisotropy for detection of wave-mixing processes

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Nonlinear optical phenomena, particularly second-harmonic generation (SHG), have long been a powerful tool to investigate the structural and electronic properties of materials. SHG is used for probing surfaces and interfaces of centrosymmetric materials, where bulk contributions are forbidden due to inversion symmetry, revealing surface-specific interactions by leveraging symmetry-breaking effects at the interface.

These techniques provide insight into the atomic-scale structure and bonding at interfaces, including chemically modified surfaces and oxide layers.

Moreover, significant advances have been made in extending SHG and related techniques to characterize anisotropies in the nonlinear response, which reflect the structural and electronic properties.

Nonlinear radiation emission in crystalline solids is highly dependent on the medium structure, in particular on the local crystalline symmetries. One example being the angular dependence on the phase-matching conditions for second-harmonic generation.

The study of the rotational anisotropy dependence of the SHG emission (RA-SHG) is an established approach to obtain information which, when compared to the predicted behaviour by dipole and quadrupole contributions, can shed light on the processes at play for a given dataset.

We recently demonstrated that looking at the power scaling at each rotation angle of the sample – i.e. to study the intensity scaling of RA-SHG – provides anisotropy information while differentiating processes mediated by different orders of non-linearity.

Using this new approach we published, to the best of our knowledge, the first second-harmonic generation mediated by a fifth-rank nonlinear susceptibility tensor in Si(111).

This is particularly intriguing as it highlights the coexistence of well-established surface SHG and a never reported χ4-mediated contribution, expanding the understanding of nonlinear interactions in Si (111), and showing that intensity scaling of RA-SHG enables sensible detection of quadratic contributions even with simple detection apparatus such as an ADC-coupled PMT.

In this work we discuss the capabilities and limitations of intensity scaling RA-SHG, both in the experimental apparatus side as well as in the data treatment, and detail the next steps for the nonlinear characterization station installed in our laboratory.

ID: 159

Engineered Plasmonic Substrates for Surface-Enhanced Raman Spectroscopy Applications

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This work presents the development of Au-based Surface-Enhanced Raman Spectroscopy (SERS) substrates and evaluates their performance for the sensitive detection of thiabendazole. C-shaped nanostructures arranged in a specific pattern were designed to achieve plasmonic resonance in the 800–900 nm spectral range, matching the Stokes-shifted Raman bands of thiabendazole under 785 nm excitation, thereby enabling efficient Raman signal enhancement. The SERS structures were fabricated on silicon substrates using electron-beam lithography (EBL). The fabrication process began with spin-coating a thin polymer film (polymethyl methacrylate, PMMA 950k A4) at 2500 rpm, followed by thermal treatment on a hot plate at 160°C for 3 min. The polymer was then exposed using a dedicated RAITH e_Line system under the following conditions: 30 kV acceleration voltage and 200 pA beam current, while proximity effects were corrected using the PECS software module. The structures were subsequently developed by immersing the wafers in a methyl isobutyl ketone (MIBK): isopropyl alcohol (IPA) solution (1:3 v/v) at 22°C for 60 s. A 90 nm Au thin film was then deposited by electron-beam vacuum evaporation using a TEMESCAL FC-2000 system, enabling a high-quality lift-off process. Finally, the patterned regions were coated with a 60 nm Au film to enhance the plasmonic response. SEM imaging confirmed the nanostructures over a 250 µm × 250 µm area (Fig.1). SERS measurements were performed using an i-Raman Plus spectrometer (BWTEK) with a fiber-optic probe and a 785 nm excitation wavelength. All measurements were conducted using a laser power of 40 mW and an integration time of 3 s. A stock solution of 1 mM TBZ in ethanol was diluted with DI water to obtain concentrations in the 1 nM–100 □M range. Fig. 2 shows the Raman intensity response at different concentrations, together with the concentration dependence of the 1453 cm 1 peak, demonstrating TBZ detection down to 10−9 M. The obtained results demonstrate the potential of our proposed approach for the sensitive and reliable detection of thiabendazole in aqueous matrices.

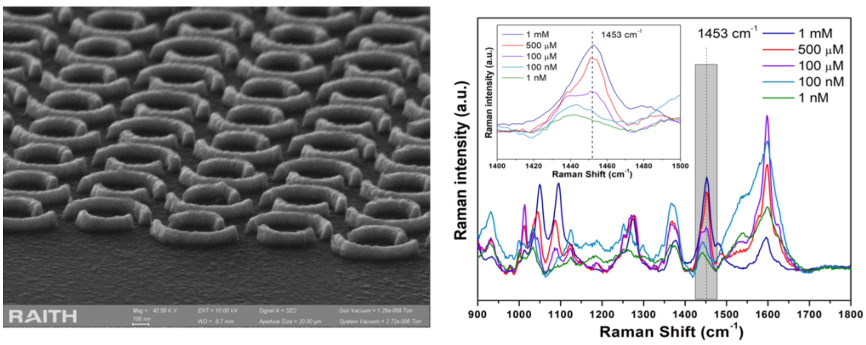

Figure - Left: SEM images of_the_SERS substrate. Right: Raman spectra TBZ in water

ID: 160

Label Free TCMPC Quantification of Singlet Oxygen Phosphorescence in 5 ALA PDT Glioma Models

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Gliomas are among the most aggressive primary brain tumors and remain difficult to treat due to diffuse infiltration and limited therapeutic selectivity. Photodynamic therapy (PDT) based on 5-aminolevulinic acid (5-ALA) is a promising light-activated approach that relies on the intracellular conversion of 5-ALA to protoporphyrin IX (PPIX) and the subsequent generation of singlet oxygen (1O2) upon red-light excitation. Reliable quantification of 1O2 formation is crucial for evaluating and optimizing PDT efficacy, yet conventional indirect reactive oxygen species assays often lack specificity and are prone to photo induced artefacts.

In this work, we present a direct, label-free optical methodology for 1O2 detection based on time-correlated multiple-photon counting (TCMPC) in the near-infrared (NIR) spectral region. Using a TCMPC-NIR system with pulsed laser excitation at 635 nm (SHB Analytics, Germany) and a photomultiplier tube/PMT (coupled with an ultrafast AD conversion and counting system), we directly recorded the weak phosphorescence of 1O2 generated in 5-ALA–treated NCH-82 human glioma cells after 24 h incubation, measured in cell suspension. Time-resolved measurements enabled real-time monitoring of intracellular 1O2 kinetics during irradiation at 90 mW/cm2 and a total fluence of 4.2 mJ/cm2 (400 ns pulse width, 12 kHz). PDT-induced cytotoxicity was independently confirmed using the sulforhodamine B assay, which showed approximately 50% reduction in cell viability under the applied conditions.

These results demonstrate the feasibility of direct optical detection of PDT-generated 1O2 in biological systems, providing a photophysical readout for mechanistic PDT studies and for future optimization of light-based glioma therapies.

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ID: 161

Enhanced Fluorescence-Based Sulfite Detection in Acidic Media with Platinum(II) Porphyrins

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Sulfites are compounds of significant interest due to their widespread application in the food and beverage industries. Particularly in winemaking, they act as preservatives because of their antioxidant properties. However, inadequate monitoring and control of sulfite levels can pose health risks and negatively impact sensorial properties, like smell and flavor. This has led to an increased interest in the development of sulfite sensors and several analytical techniques have been explored, including fluorescence-based approaches. Porphyrins and their metallo-derivatives are organic dyes with unique photophysical properties that have made them notable candidates for sulfite monitoring. However, for wine-based applications, they need to operate under specific conditions, namely at pH values between 3 and 4. In this work, the synthesis of two Platinum(II) porphyrins, $PtTPPF_{20}$ and $PtTPPF_{16}$[SCH2CH2COOH]4, is described [1]. UV–Vis absorption spectra were recorded to evaluate the effect of sulfite addition. To assess the response to sulfite concentration variations, fluorescence spectra were obtained at an excitation wavelength of 540 nm in two different media: a dimethyl sulfoxide solution (DMSO), pH $\approx$ 7, and a model wine solution (pH $\approx$ 3.3). The absorption spectra indicated that both metalloporphyrins respond to the addition of sulfites. Analysis of the emission spectra revealed two peaks at 645 nm and 705 nm. Regarding fluorescent-based experimental tests, linear regression of the peak emission intensity at 705 nm for different sulfite concentrations showed a significantly higher correlation coefficient in the acidic medium than in DMSO for both metalloporphyrins (R2 values of 0.95 and 0.51 for $PtTPPF_{20}$ and 0.99 and 0.89 for $PtTPPF_{16}$[SCH2CH2COOH]4, respectively). Both metalloporphyrins exhibited enhanced performance in acidic media, demonstrating their suitability for application in optical sensing systems for sulfite monitoring in the wine industry.

Keywords: Sulfite, Fluorescence, Sensing, Acidic Media, Metalloporphyrin.

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ID: 162

Calibration of a Time-Resolved Near-Infrared Detection System for Singlet Oxygen

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Time-resolved detection of singlet oxygen (1O2) provides direct access to the photophysical processes governing light-induced energy transfer and deactivation in complex media. Quantitative measurements are challenged by the intrinsically weak near-infrared phosphorescence intensity of 1O2 and by competing background signals, necessitating careful calibration of the detection instrumentation. In this work, singlet oxygen generation mediated by Protoporphyrin IX (PpIX) was investigated using a time-correlated multiple photon counting system optimized for near-infrared detection (TCMPC-NIR).

Singlet oxygen decay times were extracted as a function of PpIX concentration in well-defined solutions. System sensitivity was calibrated by determining the minimum detectable singlet oxygen concentrations in physiological saline, cell culture medium (DMEM), and cell lysate, with the final aim of detecting the concentration of PpIX generated by 5-ALA metabolism. Background suppression was achieved through time-resolved discrimination of delayed 1O2 phosphorescence from prompt fluorescence and detector noise. The measured decay characteristics and detection thresholds were evaluated against theoretical expectations for singlet oxygen lifetime and photon emission statistics, establishing a robust basis for quantitative time-resolved measurements in optically heterogeneous environments.

ID: 163

Ocular Optical Quality During Accommodation and Post-Stimulus Across Refractive States

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Higher-order aberrations (HOAs) play an important role in determining retinal image quality and may vary with both accommodative demand and refractive error. By evaluating higher-order aberrations during accommodative response and post-stimulus conditions, the analysis goes beyond static refraction and provides insight into how the optical system behaves under different visual conditions. This is particularly relevant because everyday vision is rarely static, but instead involves continuous changes in focus, accommodative effort, and relaxation. Subtle differences in accommodative stability may therefore translate into meaningful variations in retinal image quality, even in individuals with normal visual acuity. This study aimed to characterize the ocular HOAs in emmetropes, myopes, and hyperopes, evaluating how refractive error influences the wavefront profile during and after accommodative demand.

A total of 75 participants (36 emmetropes, 24 myopes, and 15 hyperopes) were recruited. Ocular aberrations were recorded in real-time (10 Hz) using a Shack-Hartmann aberrometer during and after accommodative stimuli of 1.00D, 2.45D, and 4.73D. The root-mean-square (RMS) of HOAs was computed for a 2.5 mm pupil radius.

The analysis revealed distinct optical patterns associated with refractive states. Regarding RMS HOA during accommodative response (AR) and residual accommodation, hyperopic subjects exhibited significantly higher values in the initial relaxed state (0.39 μm $\pm$ 0.23 μm) compared to emmetropic (0.26 μm $\pm$ 0.22 μm; $p = 0.028$) and myopic individuals (0.23 μm $\pm$ 0.11 μm; $p = 0.009$). After removal of the 4.73 D stimulus, hyperopes also showed poorer optical quality (RMS HOA = 0.44 μm $\pm$ 0.21 μm) than myopes (0.21 μm $\pm$ 0.07 μm; $p = 0.009$). No significant differences were found at the remaining stimulus levels.

Hyperopic individuals demonstrate higher HOA levels, particularly in the relaxed state and following high accommodative demand, indicating reduced optical quality compared to emmetropes and myopes. This suggests that hyperopes may have an inherent instability in their accommodative system or an incomplete ability to fully relax accommodation, resulting in persistent residual aberrations. Understanding these differences is clinically relevant, as it emphasizes the need to consider not only refractive error but also dynamic optical quality when assessing visual performance and managing refractive conditions.

ID: 164

Ocular optical quality in reduced accommodation: accommodative dysfunction vs pre-presbyopia

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Accommodation enables the eye to adjust its refractive power for clear vision at varying distances. This ability declines with age (presbyopia) but can also decrease earlier due to accommodative insufficiency (AI). While both conditions show reduced accommodative performance, whether they share underlying mechanisms remains unclear. Accommodation induces changes in the crystalline lens, particularly in higher-order aberrations (HOA), which may serve as optical cues. Comparing these changes between conditions could elucidate mechanisms of accommodative decline and enable early identification.

Participants included 18 controls, 19 AI subjects, and 11 pre-presbyopic (PP) subjects, classified via comprehensive optometric evaluation. Ocular wavefront aberrations were measured using adaptive optics with Hartmann-Shack sensing under relaxed and accommodative (2.45 D) conditions. Zernike coefficients (up to 6th order) and RMS values of HOA were analyzed statistically.

Primary spherical aberration differed significantly at relaxed state: AI showed more negative values than controls ($p=0.036$) and PP ($p=0.022$), but no differences occurred during accommodation. Secondary spherical aberration did not differ between groups. At relaxed state, RMS of HOA and 3rd-6th orders showed no differences. During accommodation, RMS differed significantly: 5th order between PP and AI ($p=0.027$), 4th order between controls and PP ($p=0.033$), and 3rd order between PP versus both controls ($p=0.033$) and AI ($p=0.016$).

Despite reduced accommodation in both PP and AI, results suggest different mechanisms. Distinct aberration patterns, particularly in primary spherical aberration, indicate AI and PP exhibit different optical behaviors, supporting that these conditions represent separate functional alterations rather than a shared process. These findings have implications for understanding accommodative decline and developing early diagnostic approaches.

ID: 165

Spherical Aberration Outcomes Following Vision Therapy in Patients with Accommodative Insufficiency

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Accommodative insufficiency is characterized by a reduced ability to respond to near visual demands, often leading to symptoms that affect near vision performance and quality of life. While vision therapy is effective in improving accommodative function, its impact on the optical quality of the eye remains less explored. Primary spherical aberration (Z(4,0)) is known to vary with accommodation and has been reported to influence the magnitude of the accommodative response. Previous studies have shown that patients with accommodative insufficiency exhibit atypical patterns of spherical aberration change during accommodation compared to subjects without accommodative dysfunctions.

Understanding whether these aberration patterns represent a cause or a consequence of accommodative insufficiency is essential. This pilot study aims to compare Z(4,0) under relaxed and accommodative conditions before and after a structured vision therapy program in patients with accommodative insufficiency.

Five subjects diagnosed with accommodative insufficiency underwent a monocular vision therapy program, including lens flipper exercises under supervision and Hart chart training at home. Z(4,0) was measured under relaxed and accommodative conditions before and after therapy using a Hartmann–Shack wavefront sensor.

A tendency toward less positive Z(4,0) was observed in the accommodated state following therapy, while the relaxed state remained negative both before and after intervention. These findings differ from the typical pattern in subjects without accommodative insufficiency, who generally present positive spherical aberration in the relaxed state and negative values during accommodation.

This is a pilot study, so results should be interpreted with caution and confirmed in larger samples. Nevertheless, the lack of changes in spherical aberration under relaxed conditions may suggest structural or geometric differences in the crystalline lens in accommodative insufficiency. On the other hand, changes during accommodation after therapy may reflect improved efficiency of the accommodative system despite a persistent atypical optical profile.

Overall, these findings support the idea that aberration patterns in accommodative insufficiency may be linked to intrinsic optical characteristics rather than being purely functional. The study highlights wavefront analysis as a useful complementary tool for understanding accommodative dysfunctions and its response to vision therapy.

ID: 166

Light-based analysis of voice frequency

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The human voice constitutes a fundamental modality of communication, whose integrity may be significantly compromised by vocal disorders, thereby adversely affecting both social interaction and overall quality of life. Conventional diagnostic methodologies predominantly rely on subjective assessments or invasive procedures, underscoring the pressing need for objective, non-invasive and reliable monitoring approaches [1].

This work presents the development and experimental evaluation of a photonic system to monitor voice fundamental frequency (f0) using an optical accelerometer with a fiber Bragg grating (FBG). The sensor architecture integrates an inertial mass coupled to a metallic structure, enabling efficient transduction of acoustically induced vibrations into quantifiable optical signals. The proposed sensing device operates by detecting strain-induced shifts in the Bragg wavelength, arising from mechanical vibrations generated during vocal emission.

Experimental validation was conducted on a cohort of seven volunteers, encompassing both male (M) and female (F) genders, and distinct vocal characteristics, over a monitoring period of 40 days. The test protocol comprised three sustained phonation trials per vowel, each including an initial 5 s silence period followed by 5 s of vocal emission; this procedure was applied to all vowels.

The results demonstrate the capability of the proposed system to accurately extract f0 and effectively discriminate between different vocal profiles. The measured f0 values agree with those reported in the literature, with higher frequencies consistently observed in female participants [2]. Additionally, temporal fluctuations in f0 were identified and correlated with physiological conditions and external influencing factors, including vocal fatigue and health-related variations.

The proposed solution offers advantages over electronic systems, including immunity to electromagnetic interference, high sensitivity, low invasiveness, and sterilization compatibility. These features support its potential as a complementary tool for vocal assessment, with applications in clinical diagnostics, continuous monitoring, and early detection of vocal disorders.

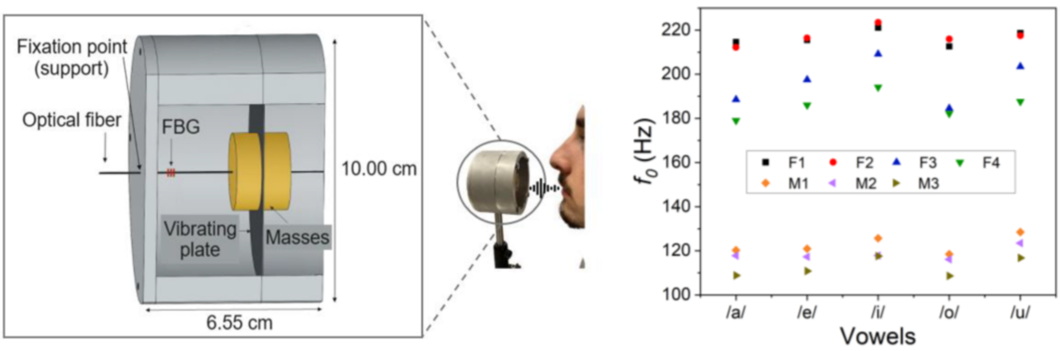

Figure - Sensor architecture and test (left), and fundamental frequency (f0) values for each volunteer and for each vowel (right).

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ID: 167

Optical Links for CubeSat Communications - Technologies and Challenges

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Transmitting large volumes of data using CubeSat platforms using Radio Frequency links is constrained by spectrum availability and achievable data rates. Optical wireless communications, provide higher bandwidth, security, and reduced interference. This paper presents a survey of optical communication systems for CubeSats, reviewing transmitters and receivers, pointing, acquisition and tracking, modulation and coding, and channel modelling for space-to-ground and inter-satellite links. It analyses constraints of CubeSat platforms, including size, weight, and power, attitude control accuracy, and atmospheric effects on propagation. Performance metrics such as data rates, link budgets, bit error rates, and system robustness are compared. The paper also identifies research areas and outlines directions for optical communication infrastructures in CubeSat constellations, including hybrid RF/optical architectures, miniaturized terminals, and quantum communication.

ID: 168

Azobenzene Relief Gratings for Reconfigurable Photonic Applications

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Azobenzene-based thin films enable light-driven surface structuring through photoinduced molecular mass transport, providing a versatile route for the fabrication of surface relief gratings (SRGs) with tunable morphology. In this work, SRGs are inscribed using interference patterns and structured optical fields, exploiting trans–cis photoisomerization to induce controlled and reversible surface modulation.

The resulting gratings exhibit well-defined periodic profiles, with their properties—such as periodicity, depth, and symmetry—governed by illumination parameters including polarization, intensity, and exposure time. Optical characterization confirms high structural quality and significant diffraction efficiencies, demonstrating strong and controllable light–matter interaction.

Beyond conventional linear gratings, the approach can be extended to more complex and spatially varying surface profiles, enabling advanced beam shaping, diffractive optics, and optical signal processing functionalities. In particular, such structures can also support the generation and manipulation of structured light, including beams carrying orbital angular momentum (OAM).

The intrinsic reversibility of azobenzene systems further enables dynamic reconfiguration, making these materials especially attractive for adaptive photonic devices, rewritable optical elements, and tunable diffractive components.

ID: 169

Nanophotonic Resonant Tunneling Diodes for Neuromorphic Applications

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The rapid evolution of software based machine learning and artificial neural network (ANN) models has intensified the demand for faster and more energy efficient computational hardware. Neuromorphic computing, particularly hardware implemented brain inspired architectures, has emerged as a promising pathway to address these challenges. Within this context, optoelectronic spiking neural networks (SNNs) offer significant advantages due to their intrinsic parallelism and low power operation.

Resonant tunneling diodes (RTDs) are nanometric semiconductor structures incorporating a double barrier quantum well (DBQW) composed of a low bandgap well (6 nm) confined between higher bandgap barriers (1.7 nm) and low doped cladding layers. Their resonant tunneling transport mechanism produces a highly nonlinear N-shaped current–voltage characteristic, enabling electrical gain, excitability, and operation at frequencies up to 1.9 THz. When combined with photosensitive or light emitting layers, RTDs become strong candidates for nanophotonic spiking neurons due to their negative differential conductance, ultrafast dynamics, and compact footprint.

In this work, we present a systematic optoelectronic characterization of RTDs incorporating photosensitive layers - RTD photodetectors (RTD-PDs). Two InGaAs/InP based epilayers were experimentally evaluated at the 1310 nm and 1550 nm optical communication windows to quantify the influence of incident light on their current–voltage characteristics, responsivity, photodetection bandwidth, and excitability behavior.

Preliminary results reveal optical power dependent peak voltage shifts whose magnitude depends on the epilayer design and biasing conditions, suggesting a strong link to the underlying band structure dynamics. A maximum responsivity exceeding 200 A/W at 1310 nm was obtained for an incident optical power of 100 µW. Furthermore, photodetection frequency response measurements on structures engineered to minimize carrier diffusion demonstrate sub nanosecond rise and fall times, confirming their potential for high speed operation.

These findings highlight the promise of optoelectronic RTDs as building blocks for ultrafast neuromorphic and optical computing platforms.

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ID: 170

Design and Synthesis of Magneto-Plasmonic Liposomes: Towards Dual-Mode Hyperthermia

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The development of hybrid nanostructures integrating magnetic and plasmonic functionalities within liposomes offers a transformative approach to cancer therapy. By combining the remote activation of magnetic nanoparticles with the LSPR of gold nanostructures, these multifunctional liposomes provide a versatile platform for dual-mode hyperthermia. Distinguishing between local surface heating and global medium temperature is crucial, as nanoscale thermal gradients can drive biological responses even when bulk temperatures remain stable. Such systems enable precise thermal control, establishing a robust path towards integrated magneto-photo-hyperthermic treatments [1-3].

In this study, multifunctional liposomes were engineered with core-shell magneto-plasmonic nanoparticles. Superparamagnetic manganese ferrite clusters were synthesized and coated with a gold shell, monitored via UV-Vis-NIR and characterized by SQUID, XRD, SEM, and DLS. For biocompatibility, a surfactant-lipid bilayer was assembled using ODT for sulfur-gold coupling and thermosensitive DODAB (Tm=45°C) as the outer layer[4]. Bilayer formation and structural integrity were validated through SEM, DLS, and FRET.

To validate photothermal efficiency, a modification of the thermosensitive Rhodamine-B probe was performed by introducing an amine terminal for conjugation onto the gold surface, enabling the measurement of the system's local surface temperature. Photothermal experiments were conducted using a fluorescence spectrophotometer setup under 808 nm laser irradiation (1 W). The resulting fluorescence intensity of the probe varies predictably with temperature fluctuations, allowing for precise local thermometry. In parallel, bulk hyperthermia was assessed under laser irradiation by monitoring the temperature of the aqueous medium. Magnetic hyperthermia was also evaluated using a dedicated system, where nanoparticles were suspended in water and subjected to two magnetic fields (AC) of biological interest: 270.0 kHz (17 mT) and 382.6 kHz (16 mT).

The nanosystems demonstrated high photothermal performance, achieving a bulk temperature increase of 20°C within 5 minutes and a surface temperature rise of 30°C in only 4 minutes. Under magnetic hyperthermia, a temperature increase of 2.5°C was observed after 10 minutes. These results demonstrate a versatile platform capable of high-intensity photothermal heating and fine-tuned magnetic hyperthermia, paving the way for optimized dual-action therapeutic protocols.

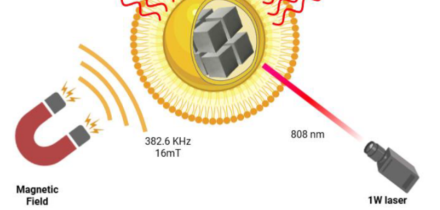

Figure - Schematic representation of the magneto-plasmonic nanosystems showing the dual-mode hyperthermia mechanisms under optical and magnetic stimulation.

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ID: 171

Tactile sensor based on multicore fiber Bragg gratings

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This study introduces a tactile sensing method using Fiber Bragg Grating (FBG) in multicore optical fibers (MCF), designed for wearable use to help therapists assess grip force at finger contact points. The mechanism relies on MCF bending under external force, causing FBGs to stretch or compress and shift the Bragg wavelength . A mechanical setup with a 3D-printed structure, metallic beam, and spring was used. When pressure is applied, the beam bends, and the FBG responds, with sensitivity of 0.8 nm/(N/mm2). The dynamic response has a rise and fall time of about 400 ms. Since the central core can't deform, it measures temperature for self-compensation, making the sensor immune to temperature changes. The design allows free movement of the MCF when pressure is applied, preventing creep issues common in polymer-embedded fiber sensors, especially useful in fast dynamic applications like finger movements. The sensor, integrated into a wearable glove, was tested successfully in real conditions, showing potential for practical tactile sensing.

ID: 172

Receiver Lens System Design Considerations for Wide-Angle FMCW LiDAR

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Automotive FMCW LiDAR demands a 120° × 20° field, 0.1° resolution, 200 m range at 10% reflectivity, 25 Hz frame rate, and operation in the 1.5–1.6 µm band. Current architectures converge on monolithic photonic integrated circuits (PICs) where emitter and coherent receiver share a silicon die. A chirped 1.55 µm beam is emitted via an on-chip optical phased array, enabling phased-array beam steering in azimuth and wavelength-tuned scanning in elevation, eliminating moving parts. The return signal is coherently mixed on-chip with a shared local oscillator, preserving phase and polarization.

On reception, a free-space objective focuses backscattered light onto a single-mode grating-coupler array. A coupler's Gaussian mode is set by three interdependent parameters: wavelength λ, waist radius w0, and far-field divergence θ. At fixed λ, étendue is fixed. Trading w0 against θ is a design optimization and leaves étendue unchanged. The objective's image-side waist and divergence must match w0 and θ under image-space telecentricity, ensuring equal étendue for every scene angle across the 100 nm band.

No published optical design satisfies this constraint set. Machine-vision lenses are not specified for 1.5–1.6 µm or single-mode arrays; F-θ scan lenses are limited to ±30°; fisheye lenses lack telecentricity; and astrophotonic systems cover smaller fields. Reported LiDAR optics are telecentric only to about ±20° or lack an extended image plane.

We address this gap analytically. The six requirements wide field, wavelength band, coupler acceptance, fixed array size, long back focal length (BFL), and telecentricity are reduced to coupled first-order laws. Image-space numerical aperture is fixed by coupler divergence (F/# $\approx$ 2–3), while focal length and entrance pupil diameter are tightly constrained by PIC coupling conditions, thereby capping photon budget scaling via étendue limits. Packaging enforces BFL/f $\gg$ 1, pushing designs toward extreme-retrofocus or afocal-relay architectures. High coupling efficiency requires field-wide normal incidence of all image-side chief rays at the grating couplers and diffraction-limited wavefront quality (Strehl $\geq$ 0.8).

Taken together, these tightly coupled constraints link aberration control, telecentricity, numerical aperture, projection geometry, chromatic correction, and chief-ray–driven tolerances, defining a narrow but viable design space bounded by PIC parameters and realized through lens architecture, topology, and optimization.

ID: 174

Integrated 3D Imaging and Spectroscopy for Cultural Heritage Analysis

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Elemental analysis of heritage objects using spectroscopic techniques allows the reconstruction of fundamental information about the history of an artefact, including the materials used (such as alloys, pigments, varnishes, adhesives, wood or stone), manufacturing techniques and possible restoration interventions. This information is essential both for educational purposes, such as exhibitions and historical studies, and for conservation practice, enabling appropriate intervention protocols that preserve the integrity and authenticity of the object.

However, these techniques are often limited to 2D representations, failing to capture the structural complexity of 3D objects. In this work, a papier-mâché mushroom sculpture is analysed using Laser-Induced Breakdown Spectroscopy (LIBS), with X-ray fluorescence (XRF) employed as a complementary technique for validation. The obtained data are integrated with a 3D model of the object, improving the visualization of the elemental composition on the object's surface.

The workflow begins with the digitisation of the object using a Creality RaptorX 3D scanner, enabling the creation of a digital twin. To reduce sensitivity to illumination variations and simplify spatial analysis, the SLIC (Simple Linear Iterative Clustering) algorithm is applied to generate superpixels, which are subsequently grouped using K-means clustering based on colour information in the CIELAB colour space. Instead of high-resolution spatial LIBS mapping, spectra are acquired from representative points within each cluster, to minimise sample damage. Finally, elemental distributions are reconstructed by assigning the spectral signatures of each cluster to the segmented regions of the 3D model. Based on the analysis of the multimodal dataset and the historical context of the collection to which the object belongs, a robust interpretation of the materials and possible pigments used in the different sections is proposed.

The developed methodology reduces the number of measurements required, increasing the efficiency of the characterisation and improving the interpretability. Beyond its relevance to cultural heritage studies, this workflow has potential applications in industrial contexts, particularly in quality control and inspection of complex and heterogeneous 3D surfaces. The integration of computer vision techniques with spectroscopy further opens perspectives for the development of automated multimodal characterisation systems.

Figure - Left: 3D model of the mushroom sculpture; Right: segmented 3D model showing five colour clusters.

ID: 175

Distributed Adaptive Road Lighting System with Predictive Anticipation Based on Edge Computing

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Nighttime road lighting requires a careful balance between energy efficiency and road safety. Traditional scheduled dimming profiles are inflexible to actual traffic variations. In contrast, reactive solutions based on local sensors may not guarantee sufficient visual adaptation time for high-speed vehicles, while centralized control platforms can introduce undesirable communication and processing latencies.

This work proposes a decentralized adaptive lighting architecture based on the Edge Computing paradigm. Each node integrates a dual-core microcontroller (ESP32), a 24 GHz FMCW mmWave radar, and DALI/PWM control. Upon detecting a vehicle, the node extracts its kinematic parameters and calculates the Estimated Time of Arrival (ETA) to the following luminaire. Detection propagation is performed via local Wi-Fi using UDP unicast, operating with sub-5 ms latency and allowing the optimal fade-in to be scheduled 500 ms prior to the vehicle's physical arrival. This creates a predictive "light wave" that seamlessly follows the traffic flow.

The validation of the finite state machine was supported by an algorithmic simulator fed with real urban traffic volume data from Lisbon. The modeled results demonstrate that the system achieves an energy saving of 41.6% compared with continuous lighting. Crucially, the model indicates that, when compared with static scheduled profiles, the system ensures full luminous anticipation for all simulated vehicle passages, with only a residual energy-consumption deviation, optimizing the energy-safety trade-off through adaptive baseline levels.

Laboratory tests confirmed hardware stability, sensor noise mitigation, and the effectiveness of fail-safe states in the presence of anomalies. Supported by low-cost components, the demonstrator validates a robust topology that mitigates shadow zones without sacrificing energy efficiency.

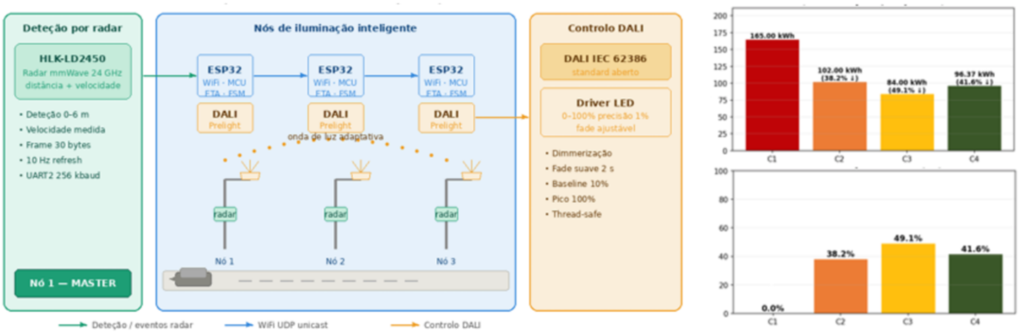

Figure - Decentralized Edge Computing Architecture with UDP predictive propagation (left) and simulated energy consumption and efficiency trade-off based on real traffic profiles (right)

ID: 176

Influence of different wavelengths on the operation of gallium oxide-based photomemristors

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Among emerging wide-bandgap semiconductors, gallium oxide (Ga2O3) has attracted significant attention for high-voltage and high-frequency power electronics. It presents five crystalline phases, among which the monoclinic β-Ga2O3 is the most stable at high temperatures. In this study, thin films of Ga2O3 were deposited by RF sputtering at powers of 200, 300, and 400 W on p-type silicon substrates for 30 or 60 minutes. Rutherford backscattering (RBS) was employed to characterize stoichiometry and thickness, and X-ray diffraction (XRD) confirmed the β-phase, while UV-Vis spectroscopy allowed bandgap calculation via reflectance data. After depositing metallic contacts, current–voltage (I–V) measurements revealed nonlinear behavior and photosensitivity. Five devices were electrically characterized to obtain key parameters such as SET and RESET voltages, exhibiting threshold switching and photoelectric response, characteristics of photomemristors. Memristors, proposed by Chua in 1971 as the fourth basic circuit element, offer resistance that can be continuously adjusted. Recent interest in photoelectric memristors stems from their ability to perform temporary memory and real-time processing of visual information, providing a hardware foundation for artificial vision systems. Ga2O3-based photomemristors were integrated into an RC circuit to emulate neuronal membrane dynamics. The first mesh (RC circuit) emulated the neuronal membrane, with measurements performed using a 16-bit PWM signal. The second mesh consisted of the memristor in series with an auxiliary resistor, in parallel with a capacitor. Total voltage and voltage across the auxiliary resistor were recorded. Regarding the material characterization, stoichiometric analysis revealed an excess of oxygen in the sputtered films, promoting defect states. Additionally, silicon diffusion from the substrate into Ga2O3 was observed, enhancing its n-type character. Despite the wide bandgap, visible light response was detected, attributed to sub-bandgap energy levels from electron-trapping defects. Finally, neuronal membrane measurements were extended with RGB LEDs and RGB laser sources to further investigate photoelectric modulation.

ID: 177

LiDAR-Based Monitoring of Railway Bogie Springs

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LiDAR technologies have become an effective tool for the geometric characterization of railway infrastructure and the detection of structural irregularities. By capturing high-resolution three-dimensional data from rails, sleepers, and surrounding elements, LiDAR enables accurate assessment of alignment, leveling, and gauge.

This work explores the capability of LiDAR sensors to evaluate the behavior of a railway bogie spring under loading conditions. Results show that geometric parameters can be retrieved when the LiDAR beam scans perpendicularly to the spring surface, while the spring height can be estimated through indirect processing.

To implement this concept, an Arduino-based experimental setup was developed using three Time-of-Flight (ToF) LiDAR sensors (VL53L4CD). Two sensors were arranged in quadrature, as previously described, while a third sensor was used to provide a reference measurement of the actual height. All sensors were connected via the I2C communication protocol, and the microcontroller was programmed to compute the average of 50 consecutive measurements in order to reduce noise and improve stability.

The system was tested on a bogie spring with a pitch of 37 mm and a wire diameter of 24 mm. The estimated pitch ranged from 37.8 mm to 38.4 mm, depending on the sensor-to-spring distance, based on a linear fit of the unwrapped phase versus height. The best performance was achieved at a distance of 120 mm.

An inversion algorithm implemented on the Arduino reconstructed the vertical position from horizontal distance measurements. Continuous phase retrieval enabled height estimation with an absolute error of approximately 5 mm. These results demonstrate the feasibility of this non-invasive approach for monitoring.

ID: 178

Polarization-Holographic Imaging Stokes Spectropolarimeter for Remote Sensing Applications

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We present the development and experimental validation of a polarization-holographic imaging Stokes spectropolarimeter (PHISSP) for remote sensing applications. The proposed instrument enables real-time, full-Stokes analysis of the state and degree of polarization of light reflected from recognizable objects. Polarization-holographic diffraction element with a complex profile of anisotropy is used in PHISSP as a single analyzing unit. The element is recorded by a special holographic schema using circularly and linearly polarized beams and special polarization-sensitive recording material. Such an element decomposes the incident light into an orthogonal basis of circular and linear polarizations. Simultaneous measurement of the intensities in all points of images of an object in the diffraction orders makes it possible to determine the spatial distribution of a polarization state across the images of extended objects, namely, all four Stokes parameters can be determined using laboratory-derived formulas and specially developed software. Corresponding polarization ellipse parameters—ellipticity, azimuth, handedness, and degree of polarization—are also available. Due to the intrinsic angular dispersion of the diffraction element, the system additionally enables analysis of the spectral dependence of polarization properties over a wide wavelength range. The operating spectral range of the polarimeter is 500 to 1600 nm with diffraction efficiency equal to 50% at 532 nm, 30% at 635 nm, and 5% at 1550 nm.

The proposed method enables the determination of correlations between the physicochemical and geometrical properties of observed objects and the distribution of the polarization state using the obtained formulas. Laboratory experiments with a prototype device demonstrate the capability to measure the state and degree of polarization of light reflected from samples from various materials with different shapes under different illumination conditions relevant to remote sensing. The method is supported by theoretical modeling.

The PHISSP contains no mechanically moving or electrically tunable optical elements, have no internal reflections, and is universal, compact, simple, user-friendly, cost-effective, and light-weight. The latter is especially important for installation on the airborne platforms.

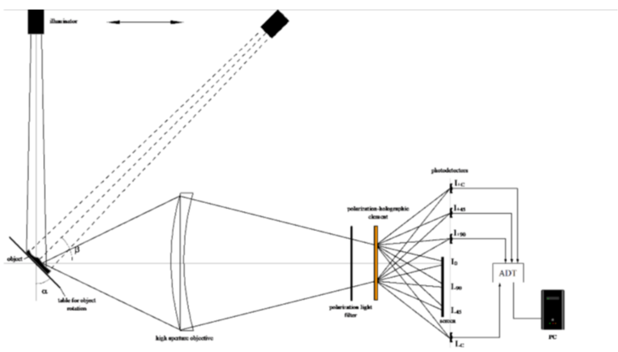

Figure - Optical scheme of the suggested method (on the left) and schematic picture of the diffraction on the polarization-holographic element (on the right).

ID: 181

Overcoming the Limitations of Pd Thin Films in SPR Hydrogen Sensors with Au@Pd Nanoparticles

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Hydrogen (H_2) has been considered the future of clean energy. However, this gas is highly explosive and flammable, making reliable and fast leak monitoring essential[1]. The Surface Plasmon Resonance (SPR) is one of the optical technologies used for sensing, with a typical configuration of a plasmonic film, a dielectric layer, and a layer of Pd. Pd layer changes its properties in the presence of H_2, changing the resonant conditions and enabling H_2 detection. Despite its good sensitivity, this type of structure is limited by the Pd thickness, which must be thin enough to avoid SPR band suppression and may pose challenges in both production and optical characterization[2].

In this work, the replacement of the Pd thin film by Au@Pd nanoparticles (NPs) is proposed. The NPs enable more controlled tuning of the SPR band at lower cost using scalable methods. Other disadvantages of Pd thin film include hysteresis, low linearity, and long response times, which can be mitigated by the use of NPs[3]. This study presents a comprehensive numerical analysis of a structure comprising an Au plasmonic layer, a TiO_2 dielectric layer, and a monolayer of NPs. The study is based on a Python script implementing the Transfer-Matrix Method and the Maxwell-Garnett Effective Medium Theory. The influence of the layers' thickness, NP size and NP density on the SPR band and H_2 sensitivity is analyzed to determine the optimized configuration.

The results indicate that the inclusion of NPs in the SPR structure can decrease the bandwidth and increase the reflectance difference between the band maximum and minimum. This behavior is opposite to that observed with Pd thin films and can help achieve more accurate optical measurements. The experimental results agree with the numerical results, confirming the feasibility of using H_2-sensitive NPs on SPR sensors.

Acknowledgements:

Acknowledgements:

This work is financed by Component 5-Capitalization and Business Innovation, integrated in the Resilience Dimension of the Recovery and Resilience Plan within the scope of the Recovery and Resilience Mechanism (MRR) of the European Union (EU), framed in the Next Generation EU, for the period 2021 - 2026, within project ATE, with reference 56. Miguel Almeida acknowledges support from FCT research grant 2023.00890.BD.

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ID: 182

Fiber Bragg gratings in PDMS membranes for real-time respiratory monitoring using edge filtering

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Monitoring vital signs, such as respiration rate, is essential in clinical settings for assessing human physiological status [1]. However, conventional techniques have certain limitations in terms of comfort and portability, and acquiring those signals is typically challenging due to their low amplitude [2]. Currently, numerous techniques are being developed to achieve higher sensitivity for this type of signal [3].

In this study, a system based on fiber Bragg gratings (FBGs) was embedded in polydimethylsiloxane (PDMS) different membranes for efficient monitoring of respiration. To optimize the sensitivity of the sensor, different membrane shapes and thicknesses were studied. The integration of these sensors into flexible structures enables the transduction of mechanical microdeformations associated with respiration into measurable optical signal variations. To enhance fast signal demodulation of the wavelength shift information, the FBG reflection signal was converted into an optical power signal using the edge filtering technique, using an AWG (Arrayed Waveguide Grating) as a passive filter of the FBG signal and a photodetector.

The preliminary results allowed the identification of the patterns related to the respiratory signal, showing the potential of the technology in wearable systems.

Acknowledgements: This work is supported by the European Union Programa FEDER, Operação n.o 15086 - COMPETE2030-FEDER- 00874200. This work is funded by national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., and, when eligible, co-funded by EU funds under project/support UID/50008/2025 – Instituto de Telecomunicações, with DOI identifier https://doi.org/10.54499/UID/50008/2025. R. Oliveira acknowledges the Scientific Employment Stimulus through contract CEECIND2021.01066, https://doi.org/10.54499/2021.01066.CEECIND/CP1653/CT0004.

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ID: 183

Will Carrier Mobilities and Lifetimes in SnS Thin Films Lead to Competitive Solar Cells ?

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Abstract

In a previous study on Tin Sulphide (SnS) thin films grown by Chemical Bath Deposition (CBD) we have extracted intrinsic defect density and energy level estimates of doping-induced defects by optical and electrical characterization. We determined absorption coefficient, refractive index, and band gap energy. The electrical properties like photo- and dark conductivity and non-radiative lifetimes were studied by coplanar electrical measurements and by contactless Microwave Transient Reflection (MWTR) using 5 ns Nd:YAG laser pulses, see reference [1].

In addition we we looked at underlying defect states in thermally annealed SnS films doped with various with small amounts of Ga, Cu and In. Finally, measurements of carrier lifetime by transient photoconductivity (TPC) were complemented by analysis of radiative recombination via transient photoluminescence (TPL) at different temperatures.

SnS has several advantages for solar cell applications due to its ideal band gap, the simplicity of thin film deposition, and the abundance of source materials [2]. Will current trends in carrier mobilities and lifetimes in SnS material allow competitive thin film solar cells ?

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ID: 184

Gallium oxide UV photodetectors for solar-blind and space applications

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Gallium oxide (Ga2O3) is an ultra-wide bandgap semiconductor (EG 5 eV, threshold wavelength 250 nm) which continues to attract interest, particularly for use in deep UV photodetectors and power electronics [1]. Sunlight reaching ground level is stripped of UV and visible light wavelengths below 280 nm, by a combination of the stratospheric ozone layer and atmospheric gases. The terrain thus appears dark when viewed by a solar-blind detector [2], sensitive only to wavelengths shorter than this. Ga2O3 photodetectors are evidently well-suited to solar-blind applications, in which the surroundings permit low levels of UVC (200-280 nm) light to be detected. Potential applications [3] of solar-blind detection include: Detection of hot flames accompanying wildfires, and missile plasma plumes; monitoring the health of the ozone layer; and as detectors in secure optical wireless communications. Applications have also been proposed in UV astronomy, as more robust chip-based low-power alternatives to photomultiplier tube imaging [4], and in industry for supervision of UVC sterilisation systems.

In this presentation, we will briefly review the material properties of gallium oxide including crystal polytypes, single crystal and thin film growth, electronic and optical properties and photodetector design, followed by a selection of the above applications. We will then address the key problems hindering future development, particularly a lack in the literature of consistent and detailed reporting of performance [5], and the protracted photocurrent rise and fall times, particularly at low signal levels, which impact applications involving high data rates such as video and telecommunications [6].

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ID: 185

CoherentStack: Modelling and Characterization of Optical Multilayer Structures Using the Transfer Matrix Method

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CoherentStack is a comprehensive software platform for the design and analysis of optical thin-film filters, featuring a graphical user interface developed in C# on the .NET Framework 4.6.1. The software employs the Transfer Matrix Method (TMM) to model light propagation through multilayer structures over a range of wavelengths or incidence angles. It supports flexible material definition, including direct input of optical constants, tabulated refractive index (n) and extinction coefficient (k) data, built-in material libraries, and dispersion models such as Cauchy and Tauc–Lorentz with user-defined parameters. An integrated stack editor enables the construction of periodic and graded multilayer systems. CoherentStack computes angle-dependent reflectance, transmittance, and absorption spectra, along with position-resolved electromagnetic fields (via the Poynting vector) and ellipsometric parameters (Ψ and Δ). The platform further incorporates a Levenberg–Marquardt optimization routine to fit experimental transmission and reflection spectra, as well as spectroscopic ellipsometry data, via adjustment of layer thicknesses and/or dispersion model parameters. By bridging theoretical modelling with practical spectroscopy and ellipsometry, CoherentStack provides a versatile environment for thin-film characterization, optical filter optimization, and device-level modelling.

ID: 186

Integrated Software Tool for Batch 3D Reconstruction Using Fringe Projection Profilometry

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Fringe projection profilometry (FPP) can deliver sub-millimetric 3D measurements with relatively accessible hardware, yet many laboratory implementations remain fragmented across separate scripts for video parsing, calibration handling, phase retrieval, unwrapping, triangulation, and inspection. This paper presents a parameterized software framework that consolidates those stages into a single, traceable workflow from raw video to 3D point clouds. The contribution of this work is an integrated architecture that (i) detects valid acquisition windows from black-to-maximum marker frames, (ii) manages camera–projector calibration with pose rejection and parameter reuse, (iii) supports both Gray-code-assisted and temporal multi-frequency absolute phase recovery, and (iv) reports intermediate quality maps and reconstruction indicators in batch mode. Experiments on Gray-code plus phase-shifting sequences show low reprojection error, high valid-pixel ratios, and stable absolute-phase continuity across varying capture conditions. These results support the use of the tool as a reproducible and quality-aware FPP workflow for laboratory-scale 3D reconstruction.

ID: 187

How Luceda empowers the PIC value chain

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As adoption of integrated photonics increases for hyperscaler applications, achieving high manufacturing yield remains a challenge due to complex requirements. High yield requires a dual approach: designers must implement variation-robust workflows, while foundries must improve fabrication processes and statistical data gathering. The Luceda Photonics design platform facilitates this by bridging multiple ecosystem entities (including simulation vendors, foundries, and assembly houses) into a unified tapeout flow. This seminar details the stages of a PIC tapeout, demonstrating how Luceda enables designers to account for subsequent manufacturing steps and achieve a PIC which behaves as expected.

ID: 188

Hydrogen Leak Detection with Optical Fibers: Implementation and Validation in Industrial Settings

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Hydrogen (H_2) as an energy vector has seen considerable planning and investment in recent years, with expanding markets and government commitments to its use in achieving net-zero emissions[1]. However, 36% of major accidents involving H_2 over the last 5 decades have been attributed to leaks in valves and connection points[1]. Thus, there is a real need for multipoint leak monitoring in infrastructure that enables safety mechanisms to be actuated quickly and reliably. Optical fiber sensors eliminate concerns about sparks or electrical discharges [2], and can operate in harsh environments while enabling remote detection and multiplexing[3]. However, increasingly shorter response times are desired to avoid fires or explosions.

Within the framework of the Energy Transition Alliance project, dedicated optical fiber gas sensors were developed and implemented. One type of sensor specifically targeted leak detection, offering a fast response time and long-term stability. The solution used a palladium-capped magnesium thin films on the tips of single-mode fibers(SMF), providing an easily detectable, cost-effective, and scalable signal that responds in under 2 seconds through a sudden drop in reflectance[4].

An interrogation system was also developed, focusing on inexpensive electronics and remote and multipoint detection capabilities. In this work, an overview of sensor development, laboratory validation and testing under industrial conditions is presented, with a focus on the implementation challenges of optical fiber gas sensors in adverse environments.

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ID: 189

Optical Wireless Communication for Cooperative Traffic Control: A VLC-Enabled Multi-Agent Reinforcement Learning Approach

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Urban traffic congestion remains a critical challenge, motivating the development of adaptive and scalable control strategies. This work presents an ongoing study on a decentralized multi-agent Deep Reinforcement Learning (DRL) framework for traffic signal optimization, explicitly supported by Visible Light Communication (VLC) as an optical wireless communication layer for real-time coordination.

In the proposed architecture, each intersection is managed by an autonomous agent that learns optimal signal phase policies based on local traffic conditions. The framework evaluates three control approaches: a fixed-time baseline, a Deep Q-Network (DQN), and a DQN enhanced with a Strategic Anti-Blocking Phase Adjustment (SAPA) mechanism, considering both vehicular and pedestrian flows across a network of nine interconnected intersections.

VLC is leveraged as a photonics-enabled communication technology, utilizing existing LED-based traffic infrastructure to provide low-latency, high-reliability, and interference-resilient data exchange between agents. This optical approach is particularly suitable for dense urban environments, where radio-frequency spectrum congestion and interference may limit scalable deployments. The integration of VLC introduces a novel dimension to cooperative traffic control, enabling efficient inter-agent synchronization through line-of-sight optical links.

Preliminary results demonstrate that DRL-based approaches significantly outperform conventional fixed-time control. In particular, the DQN+SAPA strategy improves traffic flow stability and mitigates queue spillback under high-congestion conditions. These findings highlight the effectiveness of decentralized learning when combined with optical wireless communication.

Overall, this work underscores the potential of integrating multi-agent DRL with VLC-based photonic communication systems to enable robust, scalable, and next-generation intelligent transportation solutions.

Keywords: Visible Light Communication (VLC); Optical Wireless Communication; Intelligent Transportation Systems; Deep Reinforcement Learning; Multi-Agent Systems; Smart Cities

ID: 190

Industry-compatible, hands-on training modules for PIC design, fabrication, and testing

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The demand for Photonic Integrated Circuits (PICs) has shown a significant skills gap within the integrated photonics sector. As PIC technologies expand into a wider range of applications, designers and foundries require a specific set of skills that extends beyond circuit design to include packaging, fabrication, and testing considerations.

The PIC Bootcamp training programme, offered by academic and industry partners, has been developed to address these needs by providing comprehensive, hands-on courses tailored to participants with different levels of experience. The programme provides practical training across the full PIC development cycle, covering the simulation, design, fabrication, packaging, and testing of photonic devices and circuits.

The training is organised into a series of in-person modules delivered by programme partners. The first module introduces the fundamentals of PIC components and their operation, supported by an education kit. This is followed by practical training in photonic circuit simulation and mask layout design. Participants then gain insight into fabrication tolerances and their influence on device performance through cleanroom fabrication training sessions. The final module focuses on PIC packaging and testing.

ID: 193

Overcoming Nonlinearities in High Power EDFAs for Coherent Ground-to-LEO Optical Links

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Free-space optical communications are rapidly reshaping the satellite communications landscape, outperforming radio-frequency networks in both data rates and energy efficiency. In this scenario, optical feeder links serve as the high-capacity bridge between terrestrial infrastructure and satellite networks. Atmospheric turbulence, and pointing inaccuracies, however, penalize these links, with uplink performance being further degraded by beam wandering and the so-called shower-curtain effect, whereby scattering close to the ground station strongly distorts the transmitted wavefront.

Counteracting such significant propagation losses thus requires scaling the transmitted optical power to tens of watts, which can only be achieved through dedicated high-power optical amplifiers (HPOAs). At these power levels, Kerr nonlinearities can no longer be neglected, as these inevitably accumulate in the last stages of the HPOA and in the subsequent patch-cord that delivers the signal to the telescope.

In this work, we present an analysis of the interplay between Kerr nonlinearities and amplified spontaneous emission noise in an Er-based HPOA followed by a single-mode patch-cord. Several amplifier architectures were modelled, from a simple single-stage solution to multi-section configurations combining commercial large-mode-area Erbium-doped fibers. The performance of the feeder link was then evaluated for a 400 Gbit/s DP-16QAM signal, compliant with the ESA specifications for Terabit/sec optical links. Results demonstrate that the impact of the HPOA noise figure on the link is negligible compared with the cumulative nonlinear phase rotation (NLPR), which effectively dictates the overall link performance. Our findings indicate that optimally engineered multi-section HPOAs can, by themselves, significantly mitigate self-induced nonlinear distortions. Nonetheless, the nonlinearities accumulated along the subsequent patch-cord rapidly become the dominant impairment.

The most promising route, therefore, pairs digital pre-distortion techniques, such as nonlinear phase compensation, applied at the transmitter, with optimized HPOA designs that utilize highly absorbing media and large-mode-area fibers to minimize active fiber length and the nonlinear coefficient, respectively. This joint strategy effectively overcomes HPOA and patch-cord limitations, extending the operating regime of the coherent uplink and enabling higher data rates, higher launch powers, or longer patch-cords.

ID: 194

Cellular VLC-Based Vehicle Localization Integrated with SUMO Traffic Simulation

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The increasing complexity and variability of urban traffic demand challenge the efficiency and adaptability of modern transportation systems. Traditional traffic management approaches struggle in densely populated environments with highly variable vehicular and pedestrian flows. Intelligent Transportation Systems (ITS) enable smarter mobility through Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V) communication for data-driven decision-making. However, these systems rely mainly on radio frequency (RF) technologies, which face limitations related to spectrum scarcity, interference, and reduced performance in dense scenarios.

This paper proposes a coupled VLC–traffic simulation framework in which a vehicle localization system based on Visible Light Communication (VLC) is integrated with the SUMO (Simulation of Urban MObility) platform. The system uses RGBV LED street luminaires. The system uses RGBV (Red, Green, Blue, and Violet) LED street luminaires to transmit encoded information through imperceptible light intensity modulation.These luminaires are organized into navigation cells enabling vehicle positioning from received light patterns. Each cell consists of four luminaires in a square grid, generating illumination footprints that define spatial regions with distinct signal characteristics. These optical cells are mapped onto the simulated traffic environment, enabling a discretized representation of vehicular mobility consistent with SUMO traffic dynamics.

The model is evaluated under diverse traffic scenarios. Performance metrics include localization accuracy, responsiveness, and agreement between VLC-derived positioning and simulated trajectories. Optical frame transmission behaviour is compared with simulation outputs to assess communication efficiency and system coherence.

Results demonstrate the potential of VLC as a cost-effective and infrastructure-integrated solution for vehicular localization, while validating the integration of optical cellular structures with traffic simulation models. Despite line-of-sight dependency and sensitivity to ambient light, the framework provides a pathway toward more efficient intelligent transportation systems.

ID: 195

Coherence and superradiance from a plasma-based quasiparticle accelerator

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Coherent light sources, such as free-electron lasers, provide bright beams for studies in biology, chemistry and physics. However, increasing the brightness of these sources requires progressively larger instruments, with the largest examples, such as the Linac Coherent Light Source at Stanford, being several kilometres long. It would be transformative if this scaling trend could be overcome so that compact, bright sources could be employed at universities, hospitals and industrial laboratories. Here we address this issue by rethinking the basic principles of radiation physics. At the core of our work is the introduction of quasiparticle-based light sources that rely on the collective and macroscopic motion of an ensemble of light-emitting charges to evolve and radiate in ways that would be unphysical for single charges. The underlying concept allows for temporal coherence and superradiance in new configurations, such as in plasma accelerators, providing radiation with intriguing properties and clear experimental signatures spanning nearly ten octaves in wavelength, from the terahertz to the extreme ultraviolet. The simplicity of the quasiparticle approach makes it suitable for experimental demonstrations at existing laser and accelerator facilities and also extends well beyond this case to other scenarios such as nonlinear optical configurations.

ID: 196

VLC-Enabled Multi-Agent Reinforcement Learning with Dynamic Phase Timing for Traffic Optimization

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Urban traffic congestion leads to daily delays, primarily driven by outdated, rigid control systems that rely on fixed-timing strategies. As vehicle numbers continue to grow, traditional cyclic-phase signals with predetermined timings struggle to adapt to dynamic real-time conditions. This work presents a decentralized Multi-Agent Reinforcement Learning (MARL) system designed to manage a traffic network composed of nine intersections, introducing the novel Strategic Anti-Blocking Phase Adjustment (SAPA) module to enable dynamic phase time adjustments.

The system is evaluated across three distinct traffic generation strategies based on real-world urban traffic patterns observed in cities, including morning and afternoon rush hours. Two MARL approaches are tested and compared: Deep Double Q-Network (DDQN) and Multi-Agent Proximal Policy Optimization (MAPPO), both integrated with a Visible Light Communication (VLC) infrastructure to support real-time data exchange between vehicles and infrastructure, capturing vehicle position, speed, and pedestrian presence at intersections. An ablation study is conducted to assess the impact of the SAPA module on traffic optimization. The MARL systems with adaptive phase timings are benchmarked against a baseline model employing cyclic phases with fixed durations, mirroring conventional traffic controllers observed in real-world deployments.

Results demonstrate that adaptive phase timing significantly enhances traffic flow, leading to reduced queue lengths and shorter waiting times across all tested scenarios. The MARL systems employing DDQN and MAPPO algorithms integrated with the SAPA module achieved substantial improvements compared to the baseline model, demonstrating an average reduction of 53% in queue lengths and a 60% decrease in average vehicle waiting times.

ID: 197

Photonic Enabled Multi Agent Traffic Orchestration Using Visible Light Communication for Adaptive Urban Mobility

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Photonic Enabled Multi Agent Traffic Orchestration Using Visible Light Communication for Adaptive Urban Mobility

Urban traffic congestion continues to challenge modern cities, demanding control strategies that are both adaptive and scalable. This work presents a photonic enabled multimodal traffic orchestration framework that integrates Artificial Intelligence with high bandwidth Visible Light Communication (VLC), repurposing existing LED based infrastructure as dual use optical transmitters for illumination and deterministic data exchange. By leveraging the intrinsic spatial confinement, spectral availability, and interference free nature of visible light, the system establishes a low latency optical wireless layer that supports real time coordination between intersections, vehicles, public transports and pedestrians, complementing or offloading congested radio frequency channels.

At the computational level, the urban network is modeled as a multi agent photonic aware control environment, where each intersection operates as an autonomous agent trained using Deep Q Learning, Deep Double Q Networks, and Multi Agent Proximal Policy Optimization within a Centralized Training and Decentralized Execution paradigm. A key innovation is the Strategic Anti Blocking Phase Adjustment (SAPA) module, which enables dynamic phase time adaptation to mitigate queue spillback and stabilize flow under high congestion conditions. The framework is evaluated across multiple real world–inspired traffic patterns, including morning and afternoon peak periods, and incorporates pedestrian centric perception as well as saturation driven velocity degradation modeling for public transport.

Across a nine intersection network, MARL based controllers consistently outperform conventional fixed time baselines. The integration of SAPA with DDQN and MAPPO yields substantial performance gains, including an average 53% reduction in queue lengths and a 60% decrease in vehicle waiting times, while VLC enabled optical communication enhances inter agent synchronization and scalability in dense urban environments.

Overall, this unified study demonstrates the transformative potential of combining photonic communication channels with AI driven adaptive control, establishing a robust, sustainable, and next generation framework for intelligent transportation systems and highlighting the central role of optical technologies in future smart city mobility.

ID: 199

The Development of Quantum Communication Links

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Quantum communication has emerged as one of the most significant developments in modern science and technology, offering fundamentally new approaches to secure information transfer and distributed information processing. Built on the principles of quantum mechanics, including superposition and entanglement, quantum communication provides capabilities beyond those achievable with classical systems, particularly in the area of secure communication through quantum key distribution (QKD). Over the last three decades, the field has progressed rapidly from theoretical proposals to experimental demonstrations and early-stage practical implementations, including fibre-based quantum networks, long-distance free-space links, and satellite-enabled quantum communication. These advances are laying the foundation for the future quantum internet, where quantum information will be transmitted securely and efficiently across global scales.

Despite this remarkable progress, several scientific and technological challenges remain before scalable quantum communication networks can be fully realized. Among these, the reliable transmission of quantum states through free-space channels represents a major obstacle. Atmospheric turbulence introduces fluctuations in refractive index that distort optical wavefronts, causing photon loss, decoherence, and degradation of entanglement fidelity. These effects limit transmission distance, reduce communication efficiency, and pose significant challenges for practical implementations of high-rate, long-distance quantum communication systems.

Here, we will provide an overview of the current state of quantum communication, highlighting key developments in fibre and free-space quantum links and the technologies driving the transition from proof-of-principle experiments to deployable systems. Particular attention will be given to emerging approaches aimed at improving the resilience of quantum communication channels under realistic environmental conditions.

ID: 200

Beyond Single Lasers: 2-Dimensional VCSEL Arrays

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Selectively oxidized vertical cavity surface emitting lasers today can be found in many consumer products where laser output is a few milliwatts. Higher power/brightness applications can be addressed using coherently coupled arrays and multi-junctions. We report recent results on coherently coupled photonic crystal VCSEL arrays and multi-junction high-power VCSELs.

In 1994 monolithic selectively oxidized vertical cavity surface emitting laser or *oxide-confined VCSEL* as they are commonly known as today, were invented at Sandia National Laboratories [1] and within a few years became adopted worldwide. The oxide-confined VCSEL semiconductor epitaxial structure has remained essentially unchanged for the past 3 decades due to their superior laser diode performance that is suitable for many contemporary multi-mode applications, with an estimated 1 trillion oxideconfined VCSELs deployed in total including data communication consumer products. However, restricting the lasing emission to only the lowest order Gaussian mode has been elusive for applications that require more than a few milliwatts of output.

We report on 2-dimensional photonic crystals for mode control of coherently coupled anti-guided VCSEL arrays [2] and multi-junction implant-defined VCSELs [3]. We discuss the modal characteristics and advantages of coherently coupled photonic crystal arrays [4][5] and implant-defined multi-junction VCSELs.

By combining an etched photonic crystal in the top distributed Bragg reflector mirror with spatially defined gain regions using ion implantation and selective contacts, antiguided coherently coupled VCSEL arrays can be fabricated, such as the six-ring array fabricated with a hexagonal photonic crystal pattern such as shown in Figure 1 inset. This photonic crystal has 2.6 um diameter holes on 4 µm center-to-center spacing in a hexagonal lattice. The six photonic crystal cavities are defined with missing holes and ion implantation enables independent current injection into each cavity [5].

The output power from the 940nm weakly anti-guided 6-ring arrays is shown in Figure 1 versus total injection current into the cavities. When the array elements are injected in parallel, the array output quickly becomes multi-mode above threshold where variations in fabrication lead to nonuniform current injection. Using independent injection, the currents can be tuned to provide the correct complex index profile around the ring to enable single supermode emission. This technique for mode control has been demonstrated for two-element [6] triangular [7], and 6-ring [5] photonic crystal VCSEL arrays based on an empirical search for the appropriate bias conditions.

To achieve single supermode emission, we have developed a rapid and reliable method to predict the individual bias conditions for the in-phase supermode based on prior characterization of the array. For coherent emission, all VCSELs must lase at the same wavelength; by measuring wavelength versus injection current for each element, we are able to search for array bias current combinations that yield identical wavelength in all cavities, which we will show enables prediction of the in-phase supermode bias conditions. We also consider using less than six independent sources to determine the optimal bias conditions for those sources and into which specific element of the ring-array to achieve the in-phase dominant supermode. Supermodes created from two and three injection sources are compared to that of uniform injection, demonstrating the ability to tune the array to the inphase supermode with fewer sources than independent elements in the array, simplifying the deployment of these high brightness photonic crystal VCSEL sources.

We also report modal properties of implant-defined dual-junction and triple-junction VCSELs on the path towards 10's of milliwatt single mode VCSELs.

Keywords: VCSELs, coherent arrays, photonic crystal.

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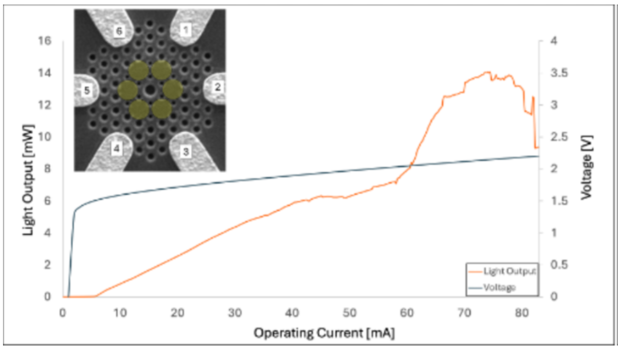

Figure - Light output versus total current to six-element photonic crystal 6-ring VCSEL array; the inset shows outline of implant cavities and selective anode contacts.

ID: 201

LIDAR beam steering via 2D amorphous silicon photonic optical phase controlled array

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Solid-state LiDAR systems based on Optical Phased Arrays (OPAs) represent a paradigm shift for autonomous vehicle perception. While hydrogenated amorphous silicon (a-Si:H) deposited via low-temperature PECVD enables cost-effective, 3D Back-End-of-Line (BEOL) integration directly on top of CMOS electronics, it introduces severe physical design challenges.

Adhering to the strict Nyquist spatial limit ($\lambda/2$) to prevent grating lobes induces detrimental optical crosstalk between adjacent sub-micrometric waveguides. Conversely, expanding the array pitch uniformly generates grating lobes, leading to angular ambiguity and ghost targets.

To overcome this trade-off, in this paper a solution based on the possibility of using broken-symmetry sparse array topologies under controlled phasis of light emitters is proposed, supported by analytical and simulative results.

A deterministic spatial jitter is introduced, making the relative distances between emitters no more uniform.

Relying on a Generalized Array Factor model derived via the Dirac delta formalism, it is proved that controlled spatial asymmetry disrupts the harmonic correlation of the cross-interference terms.

Dynamic space-time MATLAB simulations confirm that, once a least common multiple for the spatial frequencies is avoided, the constructive interference is strictly confined to the desired steering angle. Consequently, the energy typically concentrated in grating lobes is incoherently fragmented and effectively downgraded into a manageable pseudo-random side-lobe floor.

This broken-symmetry topology allows to maximize the overall optical aperture, ensuring an extremely narrow Full Width at Half Maximum (FWHM) and high directivity, while physically separating the waveguides to eliminate crosstalk.

For such structures, robust feedback controllers for phases changes is introduced.

The adopted control scheme here presented as a first choice for supporting the feasibility of the solution proposed implements a closed-loop Cyber-Physical Systems driven by Extended Kalman Filters (EKF) for noise free state estimation and Model Predictive Control (MPC) for the control signals generation.

Numerical simulations performed by Matlab for the analytic aspects and applying Maxwell's equations for studying light diffusion in and outside the circuit support the potentialities of the proposed approach.

ID: 202

Optical Methods for Self-Cleaning Assessment Across Multiple Substrates

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The assessment of self-cleaning performance in functional surfaces is commonly performed using a variety of measurement techniques. However, the lack of standardized methodologies limits reproducibility, comparability, and the selection of appropriate techniques across diverse application domains, materials, and systems, such as pavements, road markings, façades, cementitious materials, glass, textiles, coatings, polymers, and aqueous systems. In this work, a novel structured methodological framework is proposed for the evaluation of self-cleaning performance, based on optical characterization techniques, with emphasis on experimental procedures for data acquisition and the calculation of self-cleaning efficiency. The approach integrates several techniques, namely spectrophotometric colorimetry in the CIELAB space, digital image processing, UV–Vis spectroscopy, and controlled visual analysis. For each technique, the corresponding methodological procedures are defined, including acquisition conditions, experimental parameters, and calculation formulations, along with a comprehensive analysis of their capabilities and limitations. Unlike approaches focused on direct performance comparison, this work emphasizes the methodological structuring underlying each technique, highlighting their operational principles and applicability conditions across different substrates. The critical analysis of these approaches enables a consistent and reproducible evaluation of self-cleaning behavior across different smart surfaces. This work contributes to the dissemination of optical-based methodologies, providing practical guidelines for the consistent implementation of evaluation techniques in photocatalytic materials and functional surfaces. Additionally, it highlights the potential of low-cost approaches, such as digital image processing, as accessible alternatives to conventional instrumental techniques, as reported in the literature, showing high correlation values (up to R2 > 0.99) with measurements obtained using spectrophotometric methods.

ID: 203

Precision Optical Spectroscopy of Magnetoelectric Interactions in Quantum Materials

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Modern optical spectroscopy is enabling the selective measurement of microscopic interactions in complex quantum materials with unprecedented temporal, spectral, and polarization sensitivity. Advances in ultrafast and nonlinear techniques now provide direct access to collective modes, emergent couplings, and nonequilibrium phenomena that remain hidden to conventional equilibrium probes. These developments are establishing precision spectroscopy as a powerful framework for the metrology of interacting quantum systems and for investigating light–matter interactions on ultrafast timescales.

In this talk, I will present nonlinear optical approaches to investigate intertwined orders in low-dimensional quantum materials. In particular, I will discuss recent work revealing dynamical magnetoelectric coupling in atomically thin van der Waals multiferroics [1]. Using a suite of polarization-resolved ultrafast spectroscopy techniques, we directly probe coherent oscillations of electric polarization and magnetization at terahertz frequencies, uncovering giant chiral optical responses in resonance with collective electromagnon excitations.

These findings establish new opportunities for optical functionalities based on coupled electric and magnetic dynamics in quantum materials, including terahertz polarization optics, chiral photonic responses, and ultrafast magnetoelectric memory concepts operating at terahertz speeds.

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ID: 207

Development of a multispectral spatially resolved light logger

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Humans are deeply affected by light exposure, and research is still being conducted on its effects regarding sleep, health and overall well being. The type and amount of light to which a person is exposed can be measured using light loggers, which may be wearable. These devices often obtain a point-like measurement of radiation, namely irradiation, at the sensor, somewhat approximating human eye physiology. However, ganglion cells are unevenly distributed across the retina, therefore, a direction-dependent metric, such as radiance may more closely mimic the behavior of an eye.

A spatially resolved light logger prototype was developed, using nine spectral sensors integrated in a custom PCB, a camera lens with a focal length of 6 mm, a diffuser lens and a 3D printed enclosure (Figure 1). The device was calibrated so that all spectral sensors produce approximately the same output for the same input, and to correct vignetting effects introduced by the lens.

Angular tests were performed to characterize the final prototype. Additional testing was also conducted with the prototype and a webcam observing outdoor scenery for extended periods of time, the results were subsequently compared to meteorological data. Results show that the device is capable of detecting light originating from different directions and recording their spectral content.

This work was developed in the scope of the project "MeLiDos - Metrology for wearable light loggers and optical radiation dosimeters", which has received funding from the Horizon Europe (HE) EURAMET programme under grant agreement N° 22NRM05.

The costs related to the presentation of this work in the VII International Conference on Applications in Optics and Photonics were supported by project LAETA - Refa UID/50022/2025, funded by "Programa Financiamento Plurianual de Unidades de I&D" of the "Fundação para a Ciência e a Tecnologia". DOI: https://doi.org/10.54499/UID/50022/2025.

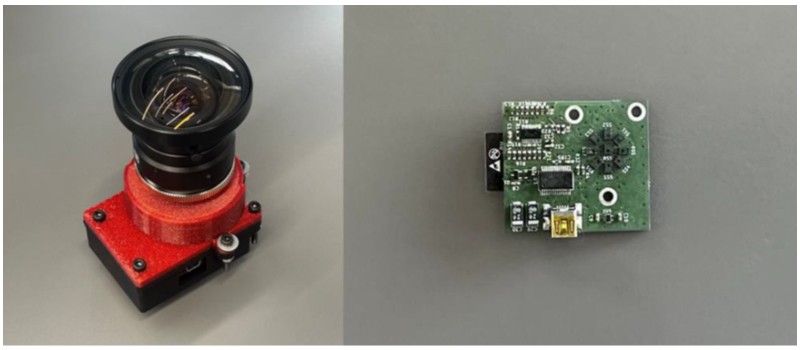

Figure - Spatially resolved light logger prototype.

ID: 208

fastplasmon - A Python toolkit for fast computation of near and far-field quantities for plasmonic nanoparticles

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Accurate prediction and optimization of localized surface plasmon resonances (LSPR) in metallic nanoparticles (NPs) remain computationally demanding for complex geometries when using full-wave electromagnetic solvers [1]. Here, we introduce an ultrafast quasistatic framework that captures the dominant dipolar response by projecting the Neumann–Poincaré surface operator $\mathcal{K}$ onto the Cartesian subspace $\{x(s), y(s), z(s)\}$. This reduces the electrostatic boundary-integral problem to a compact 3×3 generalized eigenvalue system. This projection yields geometry-dependent dipolar eigenvalues κ_n, which depend exclusively on NP shape, allowing to calculate the associated geometric amplification factor $g(\kappa_n) = (1 + 2\kappa_n)/(1 - 2\kappa_n)$.

The central result of the framework is a universal analytical expression for the refractive-index sensitivity (RIS):

$$\mathrm{RIS} = \frac{d\lambda_{\mathrm{res}}}{dn_d} = \left.\frac{2n_d\, g(\kappa_n)}{\partial_\lambda \,\mathrm{Re}\{\varepsilon_m(\lambda)\}}\right|_{\lambda=\lambda_{\mathrm{res}}}$$

This formulation explicitly separates geometry-dependent contributions from material dispersion, providing a physically transparent description of why elongated and sharp-featured NPs exhibit enhanced RIS.

The method reproduces the exact LSPR dipolar modes, showing good agreement with boundary-element-method (BEM) calculations for surface-charge distributions and extinction spectra of common geometries, such as, spheres, rods and disks. Retardation effects are incorporated through the modified long-wavelength approximation (MLWA), extending the validity of the framework into the weakly retarded regime.

Because all geometry-dependent quantities are computed only once per NP, subsequent spectral evaluations require only simple algebraic operations, enabling orders-of-magnitude speedups over conventional FDTD, DDA or BEM approaches. The framework is implemented in the open-source Python package fastplasmon `https://github.com/INESCTEC/fastplasmon`, providing an easy and fast simulation tool for geometry-driven design and optimization of plasmonic nanostructures for sensing applications.

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ID: 209

Experimental Validation and Numerical Simulation of a 520 nm Optical Wireless Power Transmission System

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Optical Wireless Power Transmission (OWPT) has emerged as a transformative technology for delivering energy across free space using high-intensity coherent or incoherent light sources. By leveraging the narrow divergence of laser beams and high-efficiency photovoltaic receivers, OWPT offers a compelling alternative to traditional radiofrequency-based charging, particularly for long-range applications such as satellite-to-satellite energy transfer. As an initial phase of the RepowerSiC project —which aims to power SiC solar cells using ultraviolet (UV) lasers— this work presents a study of OWPT operating at 520 nm over long distances. In this setup, the continuous laser light is fibre-guided and coupled to a collimator before transmission. Comprehensive numerical simulations using ANSYS Zemax OpticStudio in non-sequential mode are provided for distances of 20 m, 100 m and 1000 m, modelling the entire system including the laser source characteristics and the specific lens parameters. The optical design consists of a collimation system where the first lens (L1) has a diameter of 20 cm and a focal length of 80 cm, while the second lens (L2), with a diameter of 25 cm and a focal length of 40 cm, is positioned to focus the rays onto the detector. Experimental verification at 20 m is included, with optical power measurements performed using a power meter. A delivered power of 4.50 W was achieved from an initial optical power of 5.37 W. Numerical simulations performed for beam propagation over 20 m yielded consistent results, with a predicted power delivered of 4.46 W. Additional simulations were done in order to estimate the power transfer up to 100 m, resulting in 4.07 W at the receiver. Finally, numerical simulations for a propagation of 1000 m the revealed a delivered of power of 611 mW. This work serves to demonstrate a simple and functional optical architecture that can be subsequently extrapolated to UV wavelengths.

ID: 210

Extreme Learning Machine in Artificial Sensory Oscillator Photonic Neurons

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Recent developments in photonic neuromorphic computing, particularly oscillatory and spike-based photonic systems, are addressing the limitations of traditional von Neumann architectures and enabling new energy-efficient AI processing platforms that mimic neural functionality with low power consumption. We report an artificial sensory oscillator photonic neuron based on a III–V GaAs micropillar quantum resonant tunnelling diode (RTD) with GaAs photosensitive layers. The device can be represented by an equivalent lumped circuit and exhibits a negative differential resistance region that produces large-amplitude voltage oscillations under near-infrared illumination at approximately 830 nm, for optical intensities ranging from µW to mW. This enables the encoding of optical analog information into electrical oscillations while amplifying sensory inputs. Recent experiments have shown controlled burst-oscillation behaviour under pulse-modulated light, enabling integrated sensing, preprocessing, and encoding of analog inputs, akin to biological vision–nervous systems.

In this work, the nonlinear oscillatory behaviour of RTD photoreceivers is evaluated in the context of extreme learning machines (ELMs) for classification and regression tasks. The device equivalent circuit is modelled through nonlinear differential equations using experimental I–V data, capturing its N-shaped nonlinear response. When biased in the NDR region, the model generates self-sustained oscillations, while operation outside this region yields a steady response. Excitatory and inhibitory control is achieved using pulse-modulated light, allowing transitions between oscillatory and silent phases. The photogenerated current is used to encode information as a pulse train that perturbs the RTD dynamics, with the resulting voltage sampled and processed by a linear classifier. This approach achieves approximately 98% performance in nonlinear regression and classification tasks. For image classification, an MNIST subset using 8×8-pixel images reached about 83% accuracy, increasing to 91% when the full dataset was used with the device biased inside the NDR region. A higher-resolution 20×20-pixel subset achieved 88% accuracy. Sampling analysis showed performance variations of only around 2%, suggesting that the readout rate can be significantly reduced while maintaining robust ELM operation. To further validate this approach, photodetector micro-RTD devices are currently being fabricated.

ID: 211

Innoaqua: Innovative Approaches for an Integrated use of Algae in Sustainable Aquaculture Practices and High-Value Food Applications

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In a world facing overpopulation, resource and environmental constraints, seafood plays a crucial role as a source of provisions. However, decades of unsustainable overfishing have harmed the aquatic ecosystems. This has driven the rapid expansion of aquaculture, now one of the fastest-growing food sectors and a potential alternative to wild fisheries.

However, near-shore aquaculture expansion raises environmental concerns, including waste, dependence on wild fish for feed, disease, and invasive species. To ensure long-term viability and realize its low-carbon potential, as outlined in the EU Farm to Fork Strategy, improvements in technology and management are essential. This requires adopting circular economy principles, optimizing resource use, reducing costs, and minimizing environmental impacts.

In this context, the INNOAQUA project proposes an R&I plan to develop innovative aquaculture solutions, with a focus on algae. Accordingly, INESC TEC leads the development of digital tools to optimize biomass production. The main goal is to develop and deploy advanced sensors to collect and process data, enabling adaptive and optimized production processes.

A modular device with optical sensing was developed to monitor dissolved CO2, nitrite/nitrate, and multispectral turbidity, complemented by light and temperature sensors above and below water. Each sensing unit integrates communication and processing electronics to transmit data to advanced production systems. Architectures and technologies enabling bidirectional communication between sensors and IT systems - supporting monitoring, adaptation, and optimization - are currently under development.

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ID: 212

Novel Applications of LIBS in Recycling

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Laser-induced breakdown spectroscopy (LIBS) has become a versatile tool for elemental analysis in complex and heterogeneous materials. Its role in recycling has grown rapidly, driven by demand for high-purity secondary materials and the transition to circular manufacturing. This presentation surveys emerging applications of LIBS in recycling, with an emphasis on metals and alloy recovery.

A key advantage of LIBS is its sensitivity to light elements, enabling measurements that are difficult or impossible with X-ray-based techniques. This is particularly relevant for modern alloy systems, where small variations in elements such as lithium, magnesium, and silicon determine material performance. LIBS therefore enables new approaches to sorting and upgrading scrap streams that cannot be effectively processed using conventional technologies.

Practical deployment in recycling environments introduces constraints including high throughput, variable surface conditions, and operation in harsh industrial settings. Recent advances in instrumentation and data analysis have enabled robust in-line systems capable of real-time classification and process control at industrial scale.

Beyond metals, LIBS has been investigated for plastics recycling, particularly for black or highly pigmented materials that are not accessible to near-infrared methods. Work by Reinhold Noll and others demonstrates that polymer types can be differentiated through elemental and additive signatures, suggesting a path toward improved sorting of otherwise intractable waste streams.

An additional emerging area is lithium-ion battery recycling. LIBS offers a route to rapid characterization of "black mass," the complex mixture of cathode materials and graphite produced during processing. Its ability to detect both light elements and transition metals makes it well-suited for monitoring composition and supporting more efficient recovery of critical materials.

Together, these developments position LIBS as an enabling technology in advanced recycling processes

ID: 213

First Experimental Demonstration of Chaos-Based LiDAR in the Long-Wave Infrared Exploiting Photonic Chaos

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The long-wave infrared (LWIR) spectral region offers attractive opportunities for free-space sensing and telecommunications applications, particularly in degraded atmospheric environments where shorter wavelengths suffer from strong scattering, attenuation, and stringent eye-safety constraints. In parallel, photonic chaos generated by semiconductor lasers provides broadband, high-entropy temporal dynamics that can be exploited for correlation-based ranging and low-probability-of-intercept free-space optical (FSO) systems. In this context, we report the first experimental demonstration of a chaos-based LiDAR architecture combining the propagation advantages of LWIR wavelengths with the intrinsic robustness of photonic chaos.

The proposed system operates at 9.34 µm using a distributed-feedback quantum cascade laser (QCL) subjected to external optical feedback for photonic chaos generation. The experimental setup relies on a FSO configuration in which the chaotic emission is divided into a reference branch and a target branch. Both signals are detected using mercury–cadmium–telluride photodetectors and synchronously recorded using a real-time oscilloscope operating at 12.5 GSa/s. The estimation of target distance is performed through temporal cross-correlation between the reference and reflected signals, while spline interpolation is employed to improve the range precision.

Experimental results demonstrate reliable distance measurements over target distances ranging from 0.5 m to 10 m. The obtained cross-correlation traces exhibit well-defined peaks enabling unambiguous ranging. The system achieves meter-scale spatial resolution, with experimentally measured values reaching 0.85 m under optimized operating conditions. In parallel, sub-centimeter range precision is experimentally demonstrated across the investigated distance range.

The current performance is primarily limited by the effective chaos bandwidth and by the finite detectivity and bandwidth of available LWIR detection technologies. Nevertheless, the reported results establish a clear proof of principle for chaos-based LiDAR in the LWIR domain and highlight the potential of quantum cascade laser chaos for future free-space sensing systems combining robustness, resilience, and correlation-based ranging capabilities. Future work will investigate the behavior of the proposed architecture under degraded atmospheric conditions.

ID: 214

Characteristic-curve tracer and electrical-parameter measurement system for a photovoltaic panel powering IoT-connected devices

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With the growing adoption of renewable-energy solutions to meet energy demands, several electrical power-supply paradigms have emerged in recent years. In particular, Energy Harvesting has gained prominence as a means of powering electronic applications, notably in the context of the Internet of Things (IoT). This paradigm seeks to enable long-term, potentially perpetual operation, without reliance on the electrical grid or on batteries, thereby reducing environmental impact and maintenance costs. For photovoltaic-panel-based solutions, careful consideration must be given to the panel's placement and orientation, in order to maximize the harvested energy. Assessing this factor requires the ability to determine the photovoltaic panel's power function. The present work presents an improved analog system for tracing current–voltage (I–V) and power–voltage (P–V) characteristic curves in real-time and extracting key electrical parameters of photovoltaic (PV) panels intended to power IoT devices. These curves enable the determination of the main operating parameters, including the open-circuit voltage (VOC), short-circuit current (ISC), and maximum power point (MPP) of the PV panel. The proposed system follows a modular architecture comprising a PV panel, a measurement and sweep circuit, an Arduino-based microcontroller, and a display module. The measurement circuit integrates a controlled electronic load that progressively varies the panel operating point, sweeping from short-circuit to open-circuit conditions, while acquiring voltage and current samples. The sweeping range is automatically adapted to the maximum operating voltage of the PV panel, without needing to have any prior knowledge of its characteristics. The microcontroller digitizes the analog signals using its analog-to-digital converter (ADC) and processes the data to compute the I–V and P–V curves and the corresponding characteristic parameters. Results are displayed locally on a dedicated screen, providing a low-cost and an autonomous solution that does not rely on external instrumentation and offers a simple interface for practical use in embedded contexts. The system is thus designed to be adaptable to different low-power PV panels while balancing simplicity, accuracy, and robustness.

ID: 215

Carbon dot-based optical sensor for ferritin detection: preliminary insights

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Exploratory experiments were conducted to develop an optical sensor based on carbon dots (CDs) for ferritin detection, a clinically relevant biomarker for anaemia and early-stage cancers, including breast and lung cancers. The sensing approach relied on fluorescence detection using a multimode optical fibre. CDs were synthesized via a solvent-free thermal method using citric acid with urea (CAU) or thiourea (CAT).

The synthesized CDs exhibited maximum emission around 510 nm under 380 nm excitation. Although presenting low absolute emission quantum yields (0.02±0.01), fluorescence was successfully detected through the optical fibre, demonstrating the feasibility of the approach.

Before ferritin assays, experimental parameters, including CDs concentration (0.15 and 0.45 mg/mL), fibre core diameter (400 and 600 µm), and probe positioning were optimized. A 600 µm core diameter probe showed higher sensitivity and stability and was selected for further measurements.

Ferritin detection was evaluated within the clinically relevant range of 0-500 ng/mL, using CAU and CAT at 0.45 mg/mL. The system showed stable fluorescence over time and good reproducibility with freshly prepared solutions. Variations during repeated measurements suggest sensitivity to cumulative laser, indicating an area for further refinement of the measurement protocol.

Overall, the results reveal consistent fluorescence response trends with ferritin concentration and provide valuable insight into system performance. Although further optimization is required for robust quantitative applications, this study establishes a proof-of-concept and identifies critical parameters for improving sensor reliability and sensitivity, supporting the potential of CD-based optical fibre sensing for ferritin detection.

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ID: 216

Quantum-Kinetic Modeling of Cooperative Photoluminescence From Coupled Lifetime-Limited Organic Molecules

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We present a theoretical framework for modeling cooperative photoluminescence from pairs of dipole–dipole coupled organic molecules at low temperatures. The theory employs the density-matrix formalism based on the Bogoliubov–Born–Green–Kirkwood–Yvon (BBGKY) hierarchy for reduced density matrices and correlation operators of emitter–photon subsystems [1,2]. This approach derives the cooperative master equation from first principles, naturally incorporating dipole–dipole interaction, emitter entanglement, and collective relaxation.

The framework allows calculation of three types of spectra: photoluminescence excitation (PLE), photoluminescence emission (PL), and probe absorption/gain spectra [1,3]. The emitters are modeled as non-identical two-level systems with different transition frequencies and dipole moments driven by a cw laser beam. The excitation–detection geometry is incorporated through the relative orientations of the wave vector, polarization, and intermolecular axis. PLE spectra exhibit a characteristic triplet corresponding to superradiant, subradiant, and cascade (two-photon) cooperative emission. We demonstrate quantitative agreement with currently available experiments on cooperative photoluminescence from molecular pairs: terrylene in p-terphenyl, dibenzanthanthrene (DBATT) in naphthalene, and dibenzoterrylene (DBT) in anthracene [4]. Probe absorption and gain spectra provide complementary information about collective excited states, including transparency, amplification, and absorption bands controlled by the driving laser [3]. PL emission spectra reveal multipeak patterns sensitive to excitation strength and polarization [1]. We also report recent progress in computing the second-order photon correlation function $g^{(2)}$ as a function of excitation frequency and driving power.

The results establish a framework for predicting and controlling cooperative photoluminescence in solid-state molecular systems, with applications in quantum photonics and quantum information processing.

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ID: 217

Optical Drone-Mounted Payload for In-Flight Detection of Airborne Microplastics

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Airborne microplastics are emerging contaminants of global concern; however, their in situ detection and discrimination from other atmospheric particles remain challenging. Existing analytical methods rely mostly on lab-based spectroscopy, such as FTIR and Raman, which are accurate but slow, expensive, and incompatible with integration on mobile platforms. This work presents a proof-of-concept low-cost, compact optical system combining RGB-IR reflectance/transmission sensing with a simple LED-phototransistor transmission stage, targeting future drone-mounted deployment for airborne microplastic detection.

The RGB-IR sensor employs four reflective channels (IR, R, G, B) and three IR transmission channels and was evaluated by interrogating plastic and metal bars to discriminate plastics from metals. Two independent datasets were acquired under slightly different hardware configurations and analyzed using uni- and multivariate statistics with multiple cross-validation schemes. Reflection signals achieved large effect sizes between plastics and metals, and linear discriminant analysis reached 100% cross-validated accuracy within each dataset and 75–82% accuracy when both datasets were combined. Separately, the LED–phototransistor transmission system was characterized and shown to reliably detect features as small as 200 µm in controlled conditions. A lightweight prototype below 400 g was subsequently developed and mounted on an unmanned aerial vehicle (UAV), achieving detection of particles as small as 100 µm under conditions closer to real-world application scenarios, while also providing measurements of particle cross-sectional area.

Together, these results demonstrate that simple RGB–IR intensity features already carry substantial discriminative information for plastic–metal classification and that miniaturized optical transmission sensing is feasible for particle sizing on UAV platforms. The combined approach supports the development of low-cost, low-power optical heads as scalable building blocks for future airborne microplastics detectors on UAVs.

ID: 218

Optimization of Hybrid Electrodes for Integrated Electrochemical Surface Plasmon Resonance (eSPR) Systems

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Electrochemical Surface Plasmon Resonance (eSPR) constitutes a dual-mode analytical platform capable of label-free [1], real-time and high-sensitivity detection of molecular interactions [2]. SPR measures variations in the refractive index (RI) near a metal–dielectric interface, such as gold-water, while electrochemical measurements are usually performed in a three-electrode configuration, in which the gold chip acts as both working electrode (WE) and SPR substrate. Therefore, given the critical role of the gold chip in both sensing modes, it is essential to optimize its optical and electrochemical performance.

The hybrid electrode was fabricated via RF magnetron sputtering to produce a gold thin film onto a pre-treated glass substrate. SPR sensitivity was determined by exposing the sputtered chips to different RI solutions and measuring the absorbed wavelength. Electrochemical performance was investigated using cyclic voltammetry (CV) and square-wave voltammetry (SWV) after electrochemical activation of the surface. Further improvements were achieved by electrodeposition of gold nanostructures, creating hotspots for molecular adsorption, optical signal amplification via localized SPR (LSPR).

The SPR sensitivity showed good agreement with simulated results (1800 nm/RIU), while electrochemical characterization demonstrated high conductivity and reversible redox behavior ($I_{p,ox}/I_{p,red} \approx 1$). Annealing studies revealed enhanced electrode durability, attributed to grain growth and diffusion of the chromium adhesion layer, without compromising performance. Furthermore, electrodeposition of nanostructures led to a 30% increase in optical sensitivity while improving electrical conductivity.

This study resulted in durable and effective hybrid electrodes for the eSPR sensing system, with future work focused on sensing applications.

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ID: 219

Enhancing Optical Fibre Sensing with Zinc Oxide Tetrapod Layer Deposition

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In this work, an optical fibre sensor based on nanomaterials is proposed for determining the refractive index of aqueous solutions. A multimode (MMF) polymeric optical fibre (POF) was polished into a D-shaped sensing structure. The optical fibre surface was then modified with a thin gold layer film to stimulate surface plasmon resonance (SPR), and a second layer composed of zinc oxide tetrapods (ZnO TPs) was deposited to enhance the sensitivity to refractive index changes. The thin gold layer was deposited by sputtering, while the ZnO TPs were deposited by a simple drop-casting technique, followed by an annealing procedure. The condition of the deposited ZnO TPs was studied under scanning electron microscopy. The influence of the ZnO TPs was assessed by optical characterisation of the sensor to glucose solutions with refractive indexes in the range of 1.3340-1.3751 RIU. The sensitivity of the proposed sensor with the ZnO TPs reached 1388±36 nm/RIU, compared to the sensitivity of the POF sensor using only the thin gold layer, which was 1246±20 nm/RIU. The sensor's optical response, gold layer and ZnO TP deposition have good reproducibility and stability.

ID: 220

Differential optical sensing platform based on strong-coupled interactions between plasmonic and excitonic materials

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Surface Plasmon Polaritons (SPPs) are coupled oscillations of free electrons propagating along a metal and dielectric interface. These waves exhibit an exponential decay away from the interface, being applied in optical sensing for their high sensitivity to the environment. However, the SPP momentum exceeds the momentum of free-space propagating light, requiring bulky coupling systems for its excitation [1]. In contrast, Tamm Plasmon Polaritons are trapped along the interface between a metal and a Distributed Bragg Reflector (DBR), that provides the required momentum for direct excitation and enables fine tuning of the plasmon wavelength [2].

The push for optical integration has driven the incorporation of 2D materials, capable of manipulating light at the nanoscale. In this context, monolayer Transition Metal Dichalcogenides (TMDs) have sparked great interest in their excitonic direct bandgap at visible frequencies and extreme light-matter interactions [3].

In this work, the interaction of plasmonic and excitonic resonances is explored towards a novel sensing platform leveraging their strong-coupled regime. These interactions were analytically investigated by coupled-mode theory and numerically validated by the transfer-matrix method for the plasmonic and excitonic properties of silver and tungsten disulfide, respectively. By engineering the overlap between the plasmonic and excitonic resonances, we access the strong-coupling regime, raising two split polaritonic branches that coherently redistribute energy according to environment perturbations, enabling a high-contrast differential sensing of environment conditions by interrogation of two wavelength channels. The proposed device doubles the dynamic range of the intensity signal and self-references for noise fluctuations, improving the signal-to-noise ratio, and does not require diffractive optics or moveable parts, making it favorable for optical integration.

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ID: 222

Modeling of active waveguide Bragg gratings for thermal sensing and temperature gradient threshold detection

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Active waveguide Bragg gratings (AWBGs) are photonic structures with a periodic perturbation of the refractive index inscribed into rare-earth-doped waveguides. The efficient narrowband reflectivity of Bragg gratings (BGs) is so combined with the optical gain provided by the active medium, which may enable light amplification. Under specific conditions, these structures can operate as self-contained laser cavities [1], leading to promising photonic applications such as monolithic lasers and amplifying reflectors. The AWBG laser regime highly depends on the pumping and design parameters (length, BG coupling, attenuation), and is therefore subject to critical operating thresholds below which laser emission is suppressed [2].

Moreover, BGs exhibit high sensitivity to certain physical magnitudes, such as temperature, external refractive index, and strain. Variations in these parameters induce a spectral shift of the Bragg peak, a property now widely exploited for high-precision sensing. The use of AWBGs for this purpose would significantly improve the peak-to-background contrast: a laser peak with less than 1 nm bandwidth can be achieved several orders of magnitude above the noise floor. In addition, these variations can also reduce the BG's efficiency, potentially falling below the minimum AWBG laser operating conditions, and therefore the laser emission would stop abruptly. This makes AWBGs potential threshold-triggering switches or self-interrogating sensors, where the lasing emission is selectively activated or quenched due to external physical conditions.

In this work, the AWBGs thermal response is numerically analyzed using the Transfer Matrix Method. The Bragg wavelength shift is characterized under uniform thermal changes, revealing sensitivities of 4-11 pm/oC. The use of phosphate-based waveguides (negative thermo-optic coefficient) can minimize this shift, improving the spectral stability under moderate fluctuations. Furthermore, the BG efficiency under uniform thermal gradients along its axis is evaluated, showing a significant reduction due to the thermal chirp. When the AWBG design is considered nearby the critical laser point, it is shown to allow for a threshold-triggering detector up to 3-5oC/mm. Particularly, this would serve as a tunable thermal gradient sensor that can be adjusted through the pumping regulation.

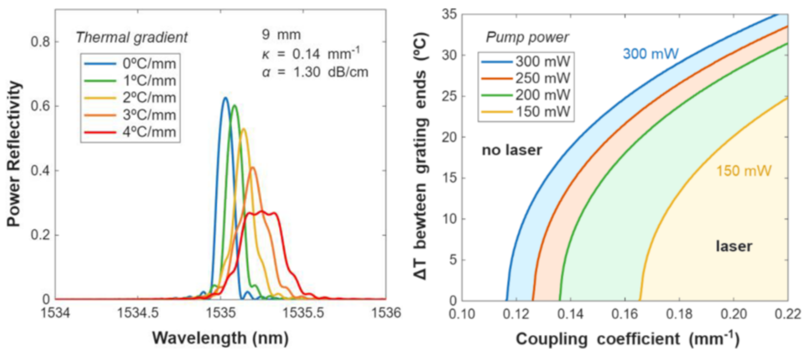

Figure - Left: BG spectral response variations of a 9 mm grating as a function of uniform thermal gradient. Right: Laser regime zones (colored) of a 9 mm AWBG as a function of the uniform thermal gradient between ends, coupling coefficient and pumping.

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ID: 223

Peripheral Defocus Myopia Control Lenses: Effects on Visual Function, Eye Movements, and Hazard Detection in Driving

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Purpose: To evaluate the effects of Defocus Incorporated Multiple Segments (DIMS) lenses on peripheral visual function and hazard prediction performance in young adult drivers.

Methods: Twenty-eight participants (aged 18–42 years) with normal visual acuity and a valid driving license completed two sessions—baseline and DIMS lens conditions—separated by a 7-day washout period. Assessments included peripheral visual acuity (PVA), peripheral contrast sensitivity (PCS), dynamic visual acuity (DVA at 5°, 10°, 15°/s), coherence dot motion (CDM), the Useful Field of View (UFOV) test, and the Hazard Prediction-Orienting (HP-O) test. Wilcoxon signed-rank tests compared performance between conditions, and Spearman correlations examined associations between visual measures and HP-O test performance.

Results: DIMS lenses produced small, non-significant reductions in PVA and PCS. Peripheral DVA at 10°/s showed a minor, non-significant decrease. CDM thresholds across coherence levels remained similar between conditions. UFOV subtests 2 (divided attention) and 3 (selective attention) exhibited mean differences of 1.4% and 13.7%, respectively, without statistical significance. HP-O test performance in simple, valid, and invalid trials was comparable across sessions. DVA at 10°/s ($\rho = 0.30$) and UFOV subtest 2 ($\rho = 0.35$) correlated with HP-O test performance, supporting their predictive value for hazard prediction.

Conclusions: DIMS lenses minimally affect peripheral vision and hazard prediction in young adult drivers. Observed changes are small and within normal variability, supporting their safety in dynamic visual tasks.

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Modelling Rate-Adaptive LEO-to-Ground Coherent WDM FSO Links with Throughput and Power Optimization

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Low-Earth-orbit (LEO) satellite constellations are reshaping global connectivity [1, 2], often employing radiofrequency (RF) communications to connect them to the ground. Due to the fierce competition for RF spectrum licenses and due to limited per-channel bandwidths, Free-Space Optical (FSO) communications have been sought as an attractive alternative, offering license-free operation, inherent transmission security and multi-Tbit/s bandwidth potential [3]. Unlocking these rates in satellite-to-ground optical feeder links (OFLs) requires careful system design, moving beyond simple single-channel intensity-modulated transceivers, towards coherent wavelength-division multiplexing (WDM) architectures [4].

FSO links, however, become highly sensitive to atmospheric conditions, where geometric losses and atmospheric turbulence lead to time-varying fading that, over a single satellite pass, strongly affects the available link budget and ultimately the per-pass throughput.

In this work, a system-level model of a coherent WDM FSO downlink is presented. The atmospheric channel is modeled by a Gamma-distributed irradiance, reproducing the stochastic fading induced by turbulence as the satellite traverses its visibility window. The optical transmission system comprises a shared on-board booster amplifier and a shared pre-amplifier before the coherent receiver, both introducing amplified spontaneous emission (ASE) noise. When coupling the time-varying atmospheric fading with the added ASE noise, the numerical testbench tracks the instantaneous signal-to-noise ratio seen by each WDM channel throughout the entire pass.

Building on this model, we investigate how to maximize the data volume delivered during a single LEO pass. An adaptive transmission scheme is proposed, in which the modulation format and the baud rate are reconfigured on-the-fly in response to the instantaneous channel state, so that the link consistently operates close to its momentary capacity instead of being dimensioned for the worst-case loss. Together with an optimization of the launched power that relaxes receiver-sensitivity requirements without overdriving on-board power consumption, this strategy is shown to noticeably enlarge the per-pass throughput of coherent WDM downlinks, supporting their evolution towards Tbit/s-class OFLs.

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ID: 225

Joint Computer Vision and Multicore-Fiber Sensing for Automatic FSO Alignment

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This work presents a hierarchical automatic alignment architecture for unidirectional Free-Space Optical (FSO) links combining computer-vision-based blind acquisition with multicore-fiber (MCF) spatial sensing for fine optical convergence.

The transmitter consists of a motorized mount holding a custom 3D-printed structure that supports both a 1550 nm collimator and a visible green laser mounted in parallel, generating two parallel optical beams. Coarse alignment is performed through a fully blind computer-vision-based search procedure, where the integrated brightness of the green beacon in the receiver side camera is iteratively maximized across two sequential alignment stages. During the final coarse alignment stage, the system simultaneously monitors the total optical power coupled into a 7-core MCF receiver, enabling a transition from coarse beacon-based alignment to fine alignment based on the maximization of fiber-coupled optical power once a predefined power threshold is reached.

A Look-Up Table (LUT), experimentally generated through raster scans over a 20 m optical path, maps multicore optical power fingerprints to transmitter displacement coordinates. Once the threshold condition is reached, the relative optical power distribution among the seven MCF cores is used to estimate the current spatial misalignment and compute the corrective displacement required to converge toward the maximum coupling position.

Experimental results demonstrate fully automatic convergence from blind initial conditions to stable maximum-power optical coupling within approximately 10 minutes, while the LUT-assisted fine alignment stage typically requires only one to three iteractions.

ID: 226

Interactive interface Software for color evaluation

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Objectives: To present an interactive interface extension of the PyFCS (Python Fuzzy Color Spaces) open-source software, that enables flexible extraction, definition, and color evaluation beyond traditional fixed color models.

Material and Methods: The system incorporates automatic and manual color extraction from images, as well as creation from scratch, allowing users to define custom color sets and construct application-specific color spaces. An evaluation module analyzes color differences using configurable thresholds, based on standard metrics such as CIEDE2000 or user-defined criteria. The interface provides visual and quantitative tools to explore relationships between colors.

Results: The interface enables intuitive and efficient visualization and evaluation under different criteria. By combining fuzzy representations with customizable thresholds, it allows fast analysis of similarity and tolerance within any defined color space. It also supports the evaluation of membership degrees of new colors with respect to predefined prototypes, together with their compliance with perceptual thresholds.

Conclusions: The proposed tool extends PyFCS by integrating interactive color extraction and flexible evaluation mechanisms into a common environment. In this context, the ability to extract colors from arbitrary images and define custom color spaces increases applicability across domains and provides a versatile and user-driven platform for efficient color analysis, supporting practical tasks such as tolerance verification, palette validation, and exploration of color relationships across application domains.

ID: 227

Experimental Bell Inequality Violation Using Constrained Measurement Geometry

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Bell inequality tests provide one of the most direct demonstrations of the incompatibility between quantum mechanics and local realistic theories [1]. Beyond their foundational relevance, Bell violations play a central role in entanglement certification, quantum communication security, certified randomness generation, and device independent quantum information processing [2–4]. Photonic implementations based on polarization entanglement are particularly attractive due to their compatibility with optical fiber networks and deployed telecommunication infrastructures [5].

Most polarization based Bell experiments employ the Clauser-Horne-Shimony-Holt (CHSH) formulation using conventional coplanar analyzer settings that maximize the Bell parameter under ideal conditions [1,6]. However, practical quantum communication systems often operate under constrained measurement settings arising from polarization drift compensation, calibration procedures, hardware limitations, or protocol dependent architectures. Consequently, Bell tests under generalized measurement geometries are of significant practical interest.

Recent studies have shown that Bell nonlocality remains observable beyond standard planar configurations, including reference frame independent tests and arbitrary Bloch sphere measurement settings [7,8]. Motivated by these developments, we investigate Bell inequality violation using a structured multi-plane measurement geometry spanning the ZX and XY planes of the Poincaré sphere. A polarization-entangled photonic system is developed and analyzed using quarter-wave plates, half-wave plates, polarizing beam splitters, and single-photon detectors.

The polarization correlations $E(a_i, b_j)$ are evaluated for the selected analyzer settings and used to reconstruct the CHSH Bell parameter

S = E(a,b)+E(a,b')+E(a',b)-E(a',b').

The results predict a clear violation of the local realistic bound |S|>2, while identifying optimal angular regions and minimum visibility thresholds for experimental implementation. These findings demonstrate that strong Bell violations remain achievable even under constrained multi-plane measurement geometries. The proposed framework is relevant for geometry aware entanglement verification in deployed fiber based quantum networks and provides a flexible platform for other inequality based nonclassicality tests employing structured polarization measurements.

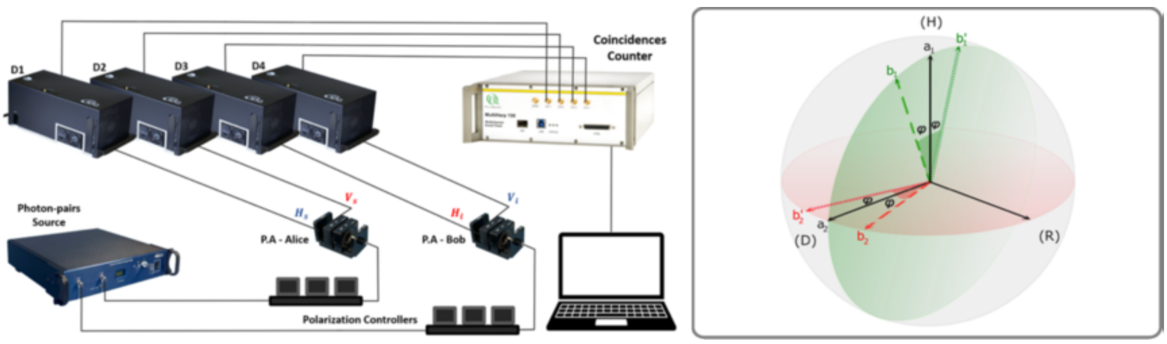

Figure - Experimental Bell test setup using entangled photons (left) and constrained multi-plane analyzer geometry on the Poincaré sphere (right).

Acknowledgements: This work was supported in part by the EU under the programs Horizon Europe R&I, through the project QSNP (GA 101114043), and EU's CEF Digital programme EuroQCI Initiative under the IberianQCI project (Grant No. 101249593), and by FCT/MCTES, through the projectUID/50008/2025

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ID: 228

Two Optical-Fiber Approaches to Embeddable Concrete Monitoring: Interferometric and Intensity-Based Methods

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Concrete is a ubiquitous construction material whose production and long-term deterioration have substantial environmental and economic impacts. This work developed two embeddable sensing systems to monitor the concrete base of a floating offshore wind turbine during curing and for long-term performance assessment.

The two systems, System 1 and System 2, use different optical approaches. System 1 is a compact, single-mode fiber system for relative humidity (RH) and temperature measurements. RH is measured with a polyvinylpyrrolidone (PVP) Fabry–Pérot cavity, and temperature is measured with a fiber Bragg grating (FBG). System 2 is a multi-parameter sensing system based on several multimode fibers. It uses four fibers, each interrogated by LED–photodiode reflectance intensity measurements. Fiber 1 has a bare tip for cure and water-ingress measurements. Fiber 2 has a tip coated with carbonated cement paste for RH measurement. Fiber 3 has a tip coated with cement paste for carbonation measurement. Fiber 4 has an Fe thin film for rebar corrosion monitoring.

Both systems were validated on lab-scale concrete specimens. System 1, which is limited by the polymer response, operates reliably in the range of 50-95% RH and up to 45 °C, with a mean uncertainty $\pm 2\%$ RH (when FBG temperature compensation is applied) and an RH response time of approximately 3 h. System 2's curing sensor is temperature-independent and strongly correlates with concrete maturity (R = 0.95). Its RH sensor is calibrated for 60–100% RH and detects water ingress/egress (>100% RH). The corrosion sensor, using colorimetric interrogation, detects reflectance changes down to −1 dB (vs. −8 dB for comparable single-mode systems). The carbonation sensor shows up to an 18% increase in reflected intensity, quantified using a pre-carbonated fiber. The whole system is calibrated for 10–60 °C.

Overall, this work represents a step toward compact and reliable optical sensing solutions for operation in harsh environments. Both solutions are currently being implemented in a large-scale concrete structure.

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ID: 229

Interchangeable-Spring FBG Extensometer for Adaptive Strain and Displacement Monitoring

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This paper presents a modular fiber Bragg grating (FBG)-based extensometer designed for high-resolution displacement and strain measurements. The proposed device employs a pure-bending aluminum beam actuated through a dual-spring mechanism with interchangeable springs, enabling straightforward adjustment of sensitivity and measurement range without requiring structural redesign. The mechanical configuration creates a constant-strain region suitable for uniform FBG interrogation. The extensometer behavior was investigated through beam theory, finite element simulations, and experimental validation. Numerical results confirmed the formation of a stable pure-bending region and a linear strain response within the elastic regime. Experimental measurements demonstrated excellent linearity between displacement and wavelength shift, with coefficients of determination approaching unity for different fiber bonding configurations at R2 = 0.999 and sensitivity of 2.16 pm/µm and 2.13 pm/µm. To enhance strain transfer efficiency, the optical fiber was chemically etched, reducing interfacial shear effects and significantly improving sensor sensitivity. The resulting system achieved sub-micrometer displacement resolution of 0.5 µm, representing an improvement of more than three times compared with conventional non-etched fibers. The proposed architecture combines high linearity, tunable mechanical response, and modular adaptability, providing a scalable and cost-effective solution for precise deformation monitoring in structural, industrial, and biomechanical applications.

ID: 230

Anterior segment OCT image features in the retro-iris space

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Background

Visualization of the posterior chamber (PC) has traditionally been limited to ultrasound biomicroscopy (UBM), as iris melanin absorption typically prevents optical penetration. Long-wavelength swept-source optical coherence tomography (SS-OCT) has improved detection of deep ocular structures; however, PC imaging remains affected by signal attenuation and backscattering artifacts. This study quantified the stochastic spatial properties of SS-OCT pixels in the retro-iridial space to support robust anatomical detection.

Methods

SS-OCT B-scans from 30 eyes (Anterion, Heidelberg Engineering) were processed to characterize intensity distributions behind the iris. Nasal and temporal regions of interest (ROIs) were extracted using the iris pigment epithelium as the anterior boundary. Signal texture was quantified using local Entropy, Standard Deviation, and Range of pixel intensity probability density functions (PDFs). Sampling employed a circular kernel with an anatomically matched radius. A Gaussian Mixture Model (GMM) was used to model signal components, with the optimal number of Gaussians determined by Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC). A consensus mask was generated by intersecting anatomical signal distributions and combining non-anatomical distributions. Performance was validated in 10 images using the Jaccard Index and a Symmetry Index comparing nasal and temporal morphology.

Results

BIC/AIC indicated that Entropy, Standard Deviation, and Range distributions were best modeled by four, two, and three Gaussian components, respectively. GMM components corresponding to anatomical regions yielded: Entropy 0.66 $\pm$ 0.05, Standard Deviation 0.11 $\pm$ 0.03, and Range 0.22 $\pm$ 0.06. The consensus mask achieved a Jaccard Index of 0.54 $\pm$ 0.07. A Symmetry Index of 0.86 $\pm$ 0.05 indicated high morphological consistency between nasal and temporal PC structures.

Conclusions

SS-OCT provides sufficient spatial information to distinguish anatomical structures from noise and artifacts in the posterior chamber. Consistent pixel statistics across the population suggest that GMM-based textural analysis is a viable framework for automated detection and biometric assessment of the ciliary body and retro-iridial space.

ID: 231

Tantalum-Enhanced Fabry-Perot Fiber Sensor for Intensity-Based Refractive Index Detection

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This work consists of a novel sensing modality based on a modal-coupling extrinsic Fabry-Perot interferometer (EFPI). The sensing configuration is based on two optical cavities, air, with variable size but below 20 μm, and borosilicate glass, with a width of 150 μm in front of the optical fiber tip. In this configuration there is no contact between the optical fiber and the analyte, which is only in contact with one face of the glass, avoiding degradation and contamination of the optical fiber. The sensor operates in a purely intensity-based regime by monitoring the measured average spectral level. Furthermore, a thin film of tantalum of 10 nm was deposited using sputtering on one analyte contact face of the borosilicate glass. Even though tantalum has a high infrared extinction coefficient, it is also a metal that can be easily oxidized. Tantalum oxide is a material with a very low extinction coefficient and a refractive index of 2.057 at 1550 nm. However, only a few nanometers are oxidized, creating two layers, a nanometric metal and dielectric. The presence of these two layers creates a complex interface between the glass and the analyte whose properties change the sensitivities and linear ranges observed. The refractive index tests were performed according to a solution of D-glucose with concentrations between 0 and 5% (w/v). When compared to the same sensor without the thin film deposition, which showed a sensitivity of 68 dB/RIU in the range between 1.33 and 1.34. The thin-film-coated version was able to increase the sensitivity up to 100 dB/RIU. The sensitivity can be further improved if the intensity for one specific wavelength is measured across the refractive index range. The results are not purely justified by the Fresnel plane-wave description, indicating a significant role of modal coupling and non-specular effects at the glass-thin film-sample interface. However, this characteristic does not pose a problem but rather an opportunity for optimization and tunability. This work highlights the potential of this EFPI configuration for compact and practical intensity-based refractive index sensing.

ID: 232

Optically Triggered Plasmonic Lipogels for Precision Melanoma Treatment

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Melanoma recurrence and metastasis following surgical excision remains one of the greatest clinical challenges, often requiring adjuvant therapies associated with systemic toxicity and limited local efficiency [1].

To address this issue, we have developed a multifunctional platform that combines localized photothermal therapy and thermo-controlled drug release. The proposed system is built on a dehydropeptide hydrogel matrix capable of incorporating thermo-responsive liposomes and plasmonic nanostructures, namely gold nanorods and gold nanoworms. Upon NIR irradiation, the latter act as efficient light-to-heat transducers, generating a localised rise in temperature within the gel network [2]. This photothermal effect promotes both the direct thermal ablation of residual melanoma cells and the controlled release of chemotherapeutic agents from the thermo-responsive liposomes [2]. The self-assembled hydrogel matrix ultimately provides mechanical stability, mouldability and localised retention at the surgical site, while ensuring spatial confinement of the liposomal and plasmonic components.

The physicochemical and functional properties of these materials were studied to evaluate their suitability for biomedical photonic applications. The plasmonic response of the gold nanostructures enabled light-to-heat conversion under NIR irradiation, while the resulting increase in liposome permeability allowed thermo-controlled modulation of the drug release profile.

These findings highlight the potential of plasmonic supramolecular lipogels as the next generation of therapeutic and, eventually, theragnostic platforms for precision oncology. The integration of photothermal conversion and thermo-induced drug release offers a powerful strategy for preventing melanoma recurrence and metastatic progression.

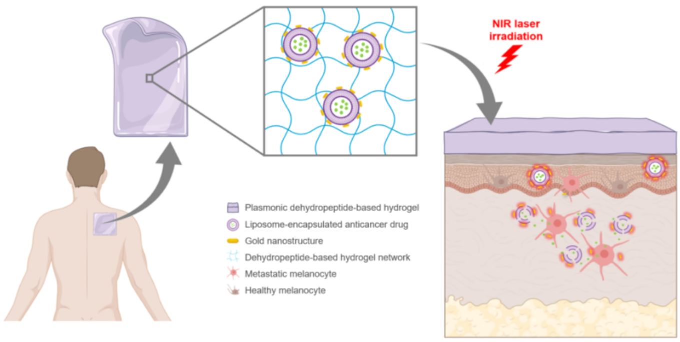

Figure - Schematic illustration of a dehydropeptide-based hydrogel containing a liposome-encapsulated anticancer drug and gold nanostructures as a platform capable of photothermal therapy and thermo-controlled drug release. Not scaled.

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ID: 233

Optical Characterization of Squid Gladius Biomaterials for Cornea Tissue Engineering

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Introduction: Cornea tissue engineering is strictly dependent on the development of biomaterials that fulfill specific optical requirements, primarily transparency. This study investigates the potential of the squid gladius (SG), a natural marine-derived structure, as a scaffold for corneal substitutes due to its inherent resistance, elasticity, and transparency.

Materials and Methods: The study compared three types of samples: native squid gladius (N-SG) disks (8 mm diameter, 1 mm thick) obtained from *Illex coindetii*, cellularized squid gladius recellularized with a corneal epithelial cell line (C-SG), and human native corneas (CTR) as controls. Optical properties were determined using the Inverse Adding-Doubling (IAD) method. Experimental values for total diffuse reflectance (MR) and transmittance (MT) were measured using a customized double-integrating sphere setup across the visible wavelength range (400–780 nm). These measurements allowed for the calculation of the absorption coefficient ($_a$) and the reduced scattering coefficient ('$_s$).

Results: Gross analysis confirmed that N-SG, C-SG, and CTR were all transparent. Spectral analysis revealed that the diffuse transmittance of both N-SG (80–85%) and C-SG (70–83%) was significantly higher than that of the CTR control (50–65%). Conversely, CTR corneas showed the highest values for diffuse reflectance (10–14%), scattering (1.5–0,7mm⁻¹), and absorption (0.2–0.4 mm⁻¹), while N-SG presented the lowest values for these parameters (5.0-5.1%; 0.4–0.5mm⁻¹; 0.01–0.15mm⁻¹). Although the recellularization process in C-SG was associated with a slight decrease in light transmittance compared to N-SG, its values remained significantly higher than those of the native human cornea.

Conclusion: These findings confirm that SG-based biomaterials possess excellent optical properties for their potential use in corneal tissue engineering.

ID: 235

Optimization of Machine Learning Algorithms for Color Prediction in Anatomically Shaped Resin-Based Dental Materials: A Pilot Study.

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Objectives: To analyze and optimize different color prediction algorithms for resin-based composite prosthetic teeth of different shades.

Methods: Monolithic samples of enamel (shades: SH1, S1, S2, S3, SSB3, SS5M2, and SSL6), dentine (shade: 2M2) and root (shades: 0M3, 1M2, 2M1, 2M2, 2M3, 3M2, and 4M2) of clinically relevant thicknesses, as well as, tooth-shaped samples of enamel (S3), dentine (2M2) and the aforementioned root shades, and tooth-shaped samples of the aforementioned enamel shades, dentine (2M2) and root (2M2) were fabricated. A non-contact spectroradiometer (CIE 45o/0o geometry) was used to measure the spectral reflectance of all samples over a black background. Reflectance values were converted into CIE-L*ab color coordinates using CIE 2o Standard Observer and CIE D65 Standard Illuminant. Eight different prediction algorithms (PLS, OLS, Ridge, Elastic Net, SVR, Random Forest, Gradient Boosting, and GPR) were developed and tested using a leave-one-out cross-validation (LOO-VC) approach. For each shade combination, the training set included the CIE-L*ab* values of the corresponding monolithic samples and six tooth-shaped samples, while the remaining tooth-shaped sample was used for testing. The dataset was divided into two subsets to assess algorithm performance separately as a function of enamel shade variations and root shade variations. Prediction performance was assessed using ΔE00 and corresponding 50:50% acceptability and perceptibility thresholds (AT00 and PT00) for dentistry.

Results: PLS and Elastic Net showed the best performance, with mean ΔE00 values between predicted and measured CIE-L*ab** coordinates of 0.58 and 0.61, respectively. For PLS, 100% of color differences were below the acceptability threshold and 71.43% were below the perceptibility threshold. For Elastic Net, 100% were below the acceptability threshold and 78.57% below the perceptibility threshold. All algorithms performed better for root shade variations than for enamel shade variations.

Conclusions: The proposed predictive methods enabled accurate color estimation of prosthetic teeth of different shades using data from monolithic samples. These results may facilitate the customized design and manufacture of dental materials and, ultimately, prosthetic teeth.

ID: 236

Molecularly Imprinted Polymer-Based Dual-Transduction Biosensor for Albumin Detection: Toward Point-of-Care Monitoring of Hypertension Biomarkers

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Hypertension (HT) is a major chronic condition and a leading risk factor for cardiovascular, cerebrovascular and renal diseases, often progressing silently until advanced stages. Early diagnosis and monitoring of HT-related biomarkers are critical for timely intervention and prevention of organ damage. Point-of-care (POC) biosensing technologies offer a promising approach for rapid and decentralized analysis [1].

In this context, this work presents a dual-transduction biosensing platform based on a gold-coated optical fiber tip (Au-OFT) functionalized with a molecularly imprinted polymer (MIP) for selective molecular recognition. The platform integrates optical and electrochemical (EC) detection in a single architecture, with the Au-OFT acting as sensing interface and working electrode, enabling complementary analytical information and signal cross-validation. Optical fibers further provide a miniaturized, highly sensitive, low-volume and real-time biosensing platform [2,3].

As proof-of-concept, human serum albumin (HSA) was selected as a biomarker associated with early kidney damage and adverse outcomes. The aim is multiplexed detection of clinically relevant cardiac and renal biomarkers, including NT-proBNP, uric acid, creatinine and albumin.

A polypyrrole-based MIP was electropolymerized on the Au-OFT in the presence of HSA, generating specific binding cavities after template removal. MIP formation and sensing performance were evaluated by surface plasmon resonance (SPR) and EC techniques. HSA rebinding produced current suppression and increased charge transfer resistance due to surface blocking, while SPR analysis showed resonance wavelength shifts induced by protein binding. The agreement between optical and EC responses validates the sensing strategy.

These results demonstrate the potential of this dual optical-electrochemical MIP-based optical fiber platform for selective biomarker detection, advancing towards a multiplexed POC system for early diagnosis and monitoring of HT-related cardiovascular and renal complications.

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ID: 237

Visible Light Communication-Enabled Reinforcement Learning for Data-Calibrated Urban Traffic Control in Lisbon

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Urban mobility systems are under increasing pressure due to the dynamic and heterogeneous nature of modern traffic demand. Despite this, traffic signal control is still largely based on fixed-time cycles. These rigid systems are inefficient as they cannot adapt to real-time variations in vehicle and pedestrian demand, often leading to unnecessary delays, increased fuel consumption, and elevated pollution in metropolitan areas. This work presents the implementation and preliminary evaluation of an intelligent traffic light control system in representative urban areas of Lisbon, using the SUMO simulator and a Double Deep Q-Network (DDQN) Reinforcement Learning architecture, supported by a Visible Light Communication (VLC)-based vehicle-to-infrastructure (V2I) network enabling low-latency optical data exchange between traffic signals and connected vehicles. The environment was calibrated using peak hour field data, capturing traffic flows of approximately 4,204 vehicles/h and 2,712 pedestrians/h, reflecting the complex mobility patterns of Lisbon's urban traffic network. The DDQN framework leverages deep neural networks to learn adaptive traffic signal control policies through continuous interaction with the simulated environment. The agents were trained using a balanced (50/50) reward function designed to minimize vehicle waiting times while ensuring pedestrian safety and priority. During training, the agents progressively refined their decision-making strategies, effectively balancing vehicular flow efficiency with pedestrian crossing demands. Simulation results indicate a clear performance improvement compared to the baseline static control system, with an overall gain of approximately 34%. In non-saturated urban corridors, the average vehicle waiting time was reduced by more than 65%. Although performance gains in vehicular flow reached saturation under heavily congested conditions, the proposed system demonstrated strong effectiveness in inclusive traffic management: pedestrian accumulation at crosswalks decreased by approximately 84% across the network, significantly improving safety and user experience for vulnerable road users. Overall, the DDQN-based adaptive control approach, enhanced by VLC infrastructure, demonstrates consistent and significant performance gains under realistic urban conditions, highlighting its potential as a robust solution for next-generation smart mobility systems.

ID: 238

Semiconductors-based Pervious Concrete for Photocatalytic Performance

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Pervious concrete pavements (PCP) are cement-based materials designed to promote water infiltration in urban environments. They are characterised by a highly porous and heterogeneous structure, consisting of an interconnected network of millimetre-scale voids and a rough macrotextured surface. From an optical perspective, these characteristics determine how light interacts with the material and the availability of photons at the surface. The photocatalytic performance of such systems is not determined exclusively by the intrinsic properties of the photocatalyst but is also influenced by light–matter interactions within the substrate. Photocatalytic coatings based on titanium dioxide (TiO2) and other alternative semiconductors are applied to PCP surfaces. The semiconductors were selected due to their distinct absorption profiles in the UV–Vis spectrum, allowing a comparative assessment of their photocatalytic behaviour under simulated solar conditions. This study examines how surface-related factors may influence the optical activation and photocatalytic performance of PCP substrates. The performance of the photocatalytic coatings is evaluated under controlled UV–Vis irradiation using the degradation of an organic dye as a model pollutant. Colorimetric analysis in the CIELab space and digital image processing (DIP) are used to assess photocatalytic efficiency and the spatial distribution of the reaction across the surface. The outcomes are intended to provide insights into how surface condition and substrate heterogeneity affect light accessibility and photocatalytic activity, supporting the development of more effective photocatalytic systems for pervious pavements.

Keywords: Pervious concrete pavements, photocatalysis, digital image processing; colorimetry.

ID: 239

The impact of noble metal thin films on SERS substrates for pesticide detection

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The engineered nanostructures, featuring 65-nanometer dot-shaped architecture arranged in periodic lattices with 100-nanometer pitch, are designed specifically to improve pesticide detection by the enhanced localized surface plasmon resonance. The primary objective is to deliver rapid, effective Raman signal amplification for terbuthylazine and its main degradation products, enabling faster environmental contaminant monitoring and surpassing the performance of conventional detection methods. The dimensions of the 65-nanometer nanodots position them within the sub-wavelength regime, allowing them to function as independent plasmonic resonators. Furthermore, the 100-nanometer pitch creates a 35-nanometer gap between adjacent nanodots, resulting in ”hot spots” exhibiting elevated electric-field intensity due to near-field coupling. This phenomenon is critical for enhancing molecular detection signals. SERS substrates with dot nanostructures were fabricated using electron-beam lithography (EBL) on 4-inch silicon wafers. The process involved spin-coating poly(methyl methacrylate) (PMMA) and patterning with a Raith e_Line system at 30 kV and 200 pA. A clearing dose of 300 µC/cm2 was applied, with proximity effect correction via PECS software. After development in MIBK: IPA (1:3) and DI water rinse, a 70 nm Au film was deposited through e-beam evaporation and patterned via lift-off. SEM imaging verified the structures over a 500 $\times$ 500 µm2 area. Finally, an additional 40 nm layer of Au, Ag, or platinum was added to enhance the plasmonic response. Raman spectra were acquired using a Horiba LabRAM HR Evolution Spectrometer with 633 nm excitation, a 50x objective, and 17 mW power for 10 seconds and 10 accumulations. The best SERS response was observed on samples on Au-Pt substrates. While platinum is usually not a SERS material due to its low dielectric constant, the enhanced signal here may result from mechanisms similar to Au-Pt core-shell structures, in which gold provides electromagnetic enhancement while platinum retains its catalytic properties. Additionally, nitrogen atoms in the analyzed materials may facilitate binding to the platinum surface, forming coordination compounds.

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ID: 240

In Situ Monitoring of Critical Safety Parameters in Lithium-Ion Batteries via Hybrid Fiber-Optic Sensing

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In response to the need for a compact technology capable of reducing the overall battery cost and determining with great accuracy the aforementioned factors, the Battery 2030+ Research Initiative, financed by the European Union, was created. An essential aspect of this mission is the development of sensors for the meticulous monitoring of internal battery parameters [1]. The INSTABAT project was a member of this initiative and aimed to research smart lithium-ion batteries (LiBs) and develop smart methodologies to sense critical parameters within the battery cells [2]. This work, developed in the scope of the INSTABAT project, represents a significant stride in enhancing the performance, safety, and understanding of this type of battery, ultimately contributing to the transition towards a more sustainable and secure energy future. The central focus of our study is the operando monitoring of commercial LiB internally by using highly sensitive optical fiber sensors (OFS). By employing an innovative hybrid sensing configuration based on fiber Bragg grating and intrinsic Fabry-Perot interferometer sensors, we have enabled the decoupling and tracking of critical safety parameters (such as temperature and pressure) inside a commercial LiB. Thereby, by correlating this data with electrochemical events during the battery operation, it was possible to evaluate their performance under several cycles at different environmental temperatures and operating conditions. Our findings challenge conventional wisdom, revealing that pressure dynamics within LiBs are associated with internal electrochemical events (such as the phase transitions of their materials) that occur during battery operation on the lithiation and delithiation

processes and mainly behave as a “breathing profile” during the successive charge/discharge steps. Our work demonstrates the immense potential of advanced OFS technology in the field of LiB monitoring, marking a substantial contribution to the realm of sustainable energy solutions. It offers invaluable insights for enhancing LiB safety, reliability, and overall performance, ultimately advancing the integration of LiBs within our evolving sustainable energy landscape.

ID: 241

An Optical Fiber-based System for Charging Batteries by Wireless Power Transfer

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This work aimed to develop a proof of concept for a battery charging system through free-space energy transfer using an optical fiber laser. To achieve this objective, a system comprising two modules was designed. The first module utilized an optical fiber ring laser emitting in the infrared region, in line with the wavelength of the fiber Bragg grating (FBG) employed. Additionally, to optimize the characteristics of the light reaching the second module, a retroreflective lens was incorporated. The second module consisted of a gallium antimonide photovoltaic (PV) cell in series with a lithium-ion battery (LiB).

The initial phase involved selecting the most suitable retroreflective lens, considering the PV cell area and irradiance, with simulations performed using Zemax software. Two types of glass were selected for the lenses (N-BK7 and S-LAH79), and variations in diameter and distances between the lens and the target (PV cell) were explored, determining the beam radius, irradiance, and total power, all on the target. The chosen retroreflective lens had a 5 mm diameter and was made of N-BK7 glass.

In the experimental system setup, an erbium-doped fiber amplifier (EDFA) and the optical fiber laser were characterized. In the latter, FBGs with different wavelength peaks and reflectivities were used. A linear increase in power as a function of the applied current was observed, and the FBG with the highest reflectivity (24%) and a Bragg wavelength of 1530 nm was selected. Additionally, laser stability tests were conducted, showing minimal oscillations on the order of (0.04 ± 0.01) mW. Next, an open-circuit voltage characterization of the PV cell was performed with varying EDFA currents to define the most suitable operating current. In the subsequent step, the distance between modules was adjusted, measuring the resulting voltage at the cell terminals to evaluate its impact. This process was repeated with the N-BK7 retroreflective lens, as indicated by the initial simulations, resulting in higher voltage values with a maximum difference of 30 mV. Finally, as validation of the proof of concept for the complete system with all components integrated, a LiB was charged at two different distances: (190 ± 1) cm and (407 ± 1) cm. In this way, the final system projected was validated with success, and the initial main goal of charging a LiB by WPT via a ring fiber laser as the proof of concept was achieved.

ID: 242

Analysis of control mechanisms for directional-coupler-based 2×2 photonic switches in amorphous silicon waveguides.

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Programmable photonic integrated circuits (PPICs) rely on tunable building blocks ca-pable of dynamically controlling the propagation of optical signals within waveguide meshes. Among these elements, directional-coupler-based 2×2 switches constitute a fundamental unit for implementing reconfigurable photonic architectures. The per-formance of these switches critically depends on the ability to accurately control the effective refractive index of the guided modes through different physical tuning mech-anisms.

This work presents a theoretical analysis of the main mechanisms used to control the effective refractive index in silicon photonic and amorphous silicon waveguides for switching applications. The thermo-optic effect, electro-optic effect, and free-carrier plasma dispersion effect are examined within a unified framework that relates the un-derlying physical phenomena to the resulting variation of the effective refractive in-dex. For each mechanism, the governing physical models are derived and analyzed, in-cluding heat diffusion and thermal RC models for thermo-optic tuning, linear and quadratic electro-optic effects (Pockels and Kerr) derived from electromagnetic consti-tutive relations, and carrier-induced refractive-index modulation.

The analysis highlights the trade-offs among tuning efficiency, switching speed, power consumption, optical losses, and integration complexity. These results provide design guidelines for selecting suitable tuning mechanisms in directional-coupler-based switches and scalable programmable photonic architectures implemented on silicon platforms.

ID: 243

Spatial Encoding and Multimode Fiber-Based Photonic Extreme Learning Machines for Efficient Optoelectronic Computing

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Optical computing has emerged as a compelling paradigm to surpass traditional electronic constraints, offering remarkable energy efficiency, massive parallelism, and the ability to process data directly within the optical domain for edge computing applications. Implementing standard Von Neumann architectures in optics is severely hindered by the lack of viable optical memory systems. To circumvent this bottleneck, artificial neural networks can be deployed, eliminating the need for optical data storage. However, realizing multi-layered optical networks is highly challenging because fabricating optical systems with precisely controllable parameters is inherently difficult. To address this, Photonic ELMs (PELMs) offer a streamlined three-layer architecture (input, hidden, and output) where the input-to-hidden mapping is performed by a fixed random matrix, requiring only the output weights (β) to be trained. Rooted in the universal approximation theorem, this framework projects low-dimensional inputs into a high-dimensional space where complex patterns become linearly separable. Crucially, β is determined via a computationally efficient closed-form expression, avoiding iterative optimization methods.

While traditional approaches rely on modulating the amplitude and phase of wavefront regions, this work investigates a novel spatial encoding scheme. In numerical simulations, this encoding is modeled by illuminating localized areas of an optical medium. Light propagation through the medium inherently computes a complex random matrix multiplication, yielding a speckle pattern that represents the hidden layer state. This speckle is captured by a camera and multiplied in silico by the trained matrix β. Numerical results confirm that the hidden layer achieves maximum or near-maximum dimensionality, displaying exceptional resilience to noise as verified by Weyl's criterion. To address hardware constraints and investigate a simplified physical architecture, we experimentally demonstrate a setup using a laser injected into a multimode fiber. The fiber is coupled at two distinct points to piezoelectric actuators; applying varying voltages deforms the fiber, modulating its propagation modes and altering the output speckle pattern. This pattern is recorded via a camera for subsequent digital processing. Our experimental findings yield highly promising results, validating the high-performance potential of this optoelectronic neural network implementation.

ID: 244

Chromatography-on-a-chip: UV-VIS detection using miniaturized amorphous silicon photosensors

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Liquid chromatography is a powerful technique widely used to separate and/or analyze complex solutions. While microfluidic technologies have strong potential for biological and biomedical applications, most platforms rely on target-specific molecular recognition using selective probes, limiting their applicability to complex samples containing multiple analytes, which often require separation-based approaches. In this work, we present a miniaturized chromatography-on-a-chip platform with integrated optical detection for point-of-care analytical applications.

The microfluidic device incorporates an injector, a microbead-packed separation chamber, and an integrated optical detector to monitor analytes as they elute from the chromatographic column. For this purpose, thin-film hydrogenated amorphous silicon (a-Si:H) photodiodes were designed and characterized for UV-Vis absorbance and fluorescence detection. The devices were fabricated using cleanroom microfabrication techniques, including sputtering, plasma-enhanced chemical vapor deposition (PECVD), photolithography, and dry etching (ICP/RIE). Different photodiode geometries were designed to ensure compatibility with the microfluidic architecture. For fluorescence measurements, optical interference filters were designed, simulated, and fabricated in-house using PECVD to enable wavelength-selective detection.

The photodiodes were characterized under zero-bias conditions, exhibiting dark currents of the order of 10−13 A and broad spectral sensitivity spanning the visible and ultraviolet ranges, with response down to 206 nm. The developed sensors enabled successful optical detection by absorbance and fluorescence. Fluorescence sensing was demonstrated using rhodamine B and Alexa Fluor 430-conjugated biomolecules, including HER2-targeted conjugates, while UV absorbance measurements were performed using analytes relevant to grape and wine analysis, including abscisic and salicylic acids. Preliminary results demonstrating analyte detection within the integrated chromatography-on-a-chip device will also be presented.

These results highlight the potential of thin-film a-Si:H photodiodes as compact, low-cost optical detectors for integrated optofluidic systems, contributing to the miniaturization and portability of analytical platforms. The incorporation of optical filtering further enhances signal quality, underscoring the versatility of the platform for multimodal optical sensing.

ID: 245

Deriving Individualized Color Matching Functions in Color Vision Deficiency with a 3D-printed Colorimeter

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Color vision deficiency (CVD), arising from anomalous or absent retinal cone photoreceptors, inherently compromises an observer's spectral discrimination capabilities. While standard colorimetric practices rely on Color Matching Functions (CMF) derived from sets of average observers, such as the CIE 1964 Standard Colorimetric Observer, these generalized metrics fail to accurately represent the individual visual response of anomalous trichromats and dichromats. Accurately quantifying individualized CMF for CVD observers remains a critical challenge for evaluating specific deficiency gradations and engineering customized optical interventions. To address this, we propose a cost-effective methodology for individualized empirical CMF derivation utilizing a custom-designed, 3D-printed compact visual colorimeter. The apparatus integrates finely tunable LED arrays and a broad-spectrum Xenon light source to project a high-fidelity bipartite field. We conducted color matching experiments employing the maximum saturation method to measure individual colorimetric data. In an initial pilot study, CMFs were successfully obtained for a control cohort of eight normal color vision observers alongside one protanope observer. Comparative analysis against the CIE 1964 standard revealed substantial inter-individual variability among normal observers, most notably within the short-wavelength (blue) spectral domain, highlighting the inherent limitations of relying solely on standardized observer models. Crucially, the protanope observer's CMFs exhibited significantly expanded matching tolerances and distinct chromatic confusion loci. These zones of elevated confusion were densely concentrated around the mid-wavelength cyan regions and the long-wavelength orange-red spectrum (610–650 nm), closely correlating with theoretical protanope confusion lines. Ultimately, this study demonstrates the experimental viability of our customized visual colorimeter.

ID: 246

Investigations of the properties of some organic and hybrid layers deposited on flat and patterned substrates

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Recently, organic thin films have emerged as promising candidates for the development of lightweight optoelectronic devices. Furthermore, structures incorporating hybrid layers with inorganic nanoparticles embedded in organic matrices, which combine the advantages of both components, have demonstrated improved performance. In this context, composite films based on CuS nanoparticles were prepared utilizing poly(3-hexylthiophene) (P3HT) and N,N-bis-(1-dodecyl)perylene-3,4,9,10 tetracarboxylic diimide (AMC14) or PCE10 in conjunction with ITIC-4F. These films were produced through spin-coating techniques on a variety of flat and patterned substrates. The UV-Nanoimprint Lithography technique has been successfully employed to create a highly ordered two-dimensional array of nanostructures resembling pillars onto the glass substrates prior to transparent electrode deposition. These pillars have a cylindrical shape with specific structural parameters, including diameters of 400-490 nm and depths of 320-420 nm, with a periodicity of 1.1 µm. Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) measurements have confirmed and characterized these features, showcasing the exceptional detail and uniformity of the nanostructures. A comparative analysis was conducted between the hybrid layers and those composed solely of organic materials. Additionally, the impact of the selected substrates on the optical and electrical properties of the structures, derived from the organic/composite layers, was assessed. The UV-VIS spectra revealed the absorption characteristics of both donor materials (P3HT or PCE10) and acceptor materials (AMC14 or ITIC-4F). Morphological investigations highlighted the distinctive features of the materials involved. It was observed that the roughness of the hybrid layers increased when deposited on flat substrates compared to the solely organic films. Moreover, substrate patterning contributed to enhanced absorption. A significant enhancement in device performance was observed for the structures created with mixed layers.

Keywords: composite layers; CuS nanoparticles; spin-coating; patterned substrates; optoelectronic devices.

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ID: 247

Solvatochromic Investigation and Quantum-Molecular Modeling of 9-Aminoacridine

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9-Aminoacridine is a green, highly fluorescent synthetic dye used as intracellular pH indicator. Due to its antiseptic, antimicrobial, anti-inflammatory and antiparasitic properties, 9-aminoacridine is present in several applications in medicine. Thus, as antiseptic agent, in form of hydrochloride salt, it is used in eye drops for the treatment of superficial eye infections. As antimicrobial agent, it is used as adjuvant of rifampin against multidrug-resistant Klebsiella penumoniae. Recent results proved that 9-aminoacridine is an inhibitor of HIV-1 virus, as well as an antitumoral agent, by intercalating into the DNA and inhibiting the replication process (mutagen effect). In mass spectrometry, 9-aminoacridine is used as a MALDI (matrix-assisted laser desorption/ionization) matrix material in the analysis of low molecular weights complex compounds, like phospholipids, fat acids or some metabolites.

In the present study, the optical spectra of 9-aminoacridine were experimentally recorded in both binary (by using 31 solvents) and ternary (binary mixtures water – ethanol, water – methanol and water – 1-propanol) solutions. The shifts of the electronic absorption bands were analyzed through several models and important information was obtained on the weight of each type of intermolecular interactions to the total shift of the spectral bands, the composition of the cybotactic region of 9-aminoacridine molecule in ternary solutions, the energy of the interaction between the molecules of solute and solvent, respectively, as well as the role of the 1:1 complex formed by the two solvents molecules in ternary solutions.

The quantum-molecular modeling, made with the help of Spartan'24 software, estimated the values of some parameters of 9-aminoacridine molecule, such as the polarizability and electric dipole moment in the ground state, polar surface area, partition coefficient, area and volume. Also, the maps of the frontier molecular orbitals (HOMO – highest occupied molecular orbital and LUMO – lowest unoccupied molecular orbital), electrostatic potential, local ionization potential and electrostatic charge per atom were obtained.

ID: 248

Estimation of the Electric Dipole Moment in the First Excited State of Trypan Blue Molecule from Solvatochromic Data

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Trypan blue is an azo dye, extensively used as vital dye in ophthalmology, as a surgical aid during cataract, vitreoretinal and corneal eye surgery, or bioscience, to selectively color in blue the dead tissues or cells. It is also used as a dye for cotton textiles, leather and paper, as well as antiparasitic veterinary drug to treat Babesia canis.

Solvatochromism describes the color change of a solution when a chemical compound is dissolved in solvents with different polarities. The shift in the wavelength depends on different parameters of the solute and solvent molecules, such as the refractive index, dielectric constant, polarizability or electric dipole moment. Solvatochromic data allows for the estimation of the first excited state electric dipole moment of a molecule, a very important parameter involved in the response of the molecule to electric field or light.

The aim of this study is to estimate the value of the electric dipole moment of trypan blue molecule in the first excited state from solvatochromic data. For this, the UV-VIS absorption spectra of trypan blue were recorded in several solvents, and the shift of the electronic absorption spectral band was analyzed by two models: Abe's model [1] and variational method proposed by Dorohoi [2]. The values obtained for the first excited state dipole moment are in very good agreement.

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ID: 249

Optical Wireless AGV Navigation and Coordination Using Visible Light Communication

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This work presents a Visible Light Communication (VLC)-based architecture for indoor navigation, coordination and traffic management of Autonomous Guided Vehicle (AGV) fleets operating in automated warehouse environments. The proposed architecture exploits RGBV LED sources integrated into ceiling luminaires, wall-mounted signalling units and AGV headlamps to simultaneously provide illumination, precise positioning and bidirectional optical wireless communication, supporting energy-efficient and sustainable Industry 4.0 logistics infrastructures.

The system supports multiple communication modes, including AGV-to-AGV (A2A), AGV-to-infrastructure (A2I), infrastructure-to-AGV (I2A) and lamp-to-vehicle (L2A), enabling real-time exchange of information related to localisation, velocity and routing. VLC links employ On-Off Keying (OOK) modulation with structured 64-bit data frames, enhanced by parity-based error detection and correction mechanisms to improve robustness under multipath propagation and ambient optical noise. To mitigate signal degradation in dense AGV clusters and occlusion scenarios, the VLC layer can operate within a hybrid communication architecture, complemented by a conceptual RF fallback channel ensuring communication redundancy and system resilience.

System-level performance is evaluated using a modified Simulation of Urban MObility (SUMO) environment adapted to indoor logistics scenarios. AGV dynamics and intersection management are governed by a Multi-Agent Reinforcement Learning (MARL) controller, further enhanced by a Strategic Anti-Blocking Phase Adjustment (SAPA) module that dynamically optimises traffic signal phases based on local and downstream occupancy, preventing congestion spillback in high-density conditions. Results demonstrate stable operation up to 350 AGVs/hour, with a 33% reduction in queue lengths and an 11% improvement in travel efficiency compared with fixed-time control strategies.

At the physical layer, specialised a-SiC:H/a-Si:H multilayer photodiodes are employed to mitigate ambient light interference, ensuring reliable optical reception under realistic warehouse illumination conditions. The proposed VLC-enabled hybrid architecture demonstrates strong potential as a scalable, interference-resilient and low-cost solution for advanced smart warehouse automation and industrial photonics applications.

ID: 250

Acoustic Detection and Source Localization with Event-Based Fiber Speckle Sensing

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The increase of underwater applications, including offshore infrastructure monitoring, maritime security, and environmental observation, is increasing the demand for compact and real-time acoustic sensing systems. Acoustics are especially important underwater, where low visibility and scattering limit optical imaging. Current solutions still rely on piezoelectric hydrophones, which can be bulky, costly, and bandwidth limited. Optical fiber sensors are a promising alternative due to their compactness, immunity to electromagnetic interference, and robustness in harsh environments, but many implementations still require specialized fibers or highly complex interrogation systems.

Speckle-based sensing in multimode fibers provides an alternative approach, where acoustic perturbations modify modal interference and produce changes in the output speckle pattern. Instead of using frame-based CMOS or CCD cameras, which are limited in temporal resolution and generate redundant data, we interrogate the speckle patterns with an event-based vision sensor (EVS). By responding asynchronously to pixel-level intensity changes, the EVS enables higher temporal resolution, lower data volume, and simultaneous monitoring of multiple fibers within the same field of view.

In this work, we demonstrate a speckle-based sensing system for acoustic detection and source localization. The output speckle pattern was projected onto an EVS, and linear polarization control was used to adjust the optical power and improve the detected speckle response. The system was first characterized in air, for acoustic frequencies between 1 Hz to 1 kHz, and detected acoustic excitation at source-to-fiber distances up to 1 m with a signal-to-noise ratio of 20 dB. We then evaluated the same sensing principle underwater in a water tank using an EvoLogics 18/34 horizontally omnidirectional acoustic modem emitting signals between 18 and 34 kHz. With the fiber submerged, acoustic signals were detected at distances up to 3 m. Finally, as proof of concept, the system was evaluated for surface-based localization, where event-camera-derived time-delay features are mapped to acoustic impact positions through a K-nearest-neighbor regression model. The preliminary results demonstrate the potential of the proposed approach for surface-based impact localization over a 1.3 m $\times$ 0.4 m area, while further refinement is expected to enhance localization accuracy and robustness.

ID: 251

Integrated Photonics for Quantum Applications

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Quantum information is an approach to information processing that combines concepts from quantum mechanics and information theory. It enables a range of methods and algorithms that offer advantages for specific tasks across different applications, including physically secure communications, measurements beyond the shot-noise limit, efficient simulation of quantum systems, and quantum computation. At its core, quantum technologies rely on physical systems that can: (1) generate well-defined quantum states exhibiting key phenomena such as entanglement and superposition, (2) be precisely manipulated, and (3) be accurately characterised.

A variety of physical platforms, including optical systems, can be used to implement quantum technologies. Photons are particularly well suited as information carriers and also offer strong performance in sensing and metrology. Quantum states of light can be generated, manipulated, and measured using standard optical components such as beam splitters, phase shifters, mirrors, lasers, and detectors. However, the implementation of more complex quantum applications requires levels of scalability and stability that are difficult to achieve with discrete components.

Integrated photonics addresses these limitations by providing material platforms based on semiconductor fabrication technologies, enabling the realisation of complex, reproducible, and phase-stable photonic circuits. Initially developed for telecommunications, integrated photonics now benefits from a mature set of components and design tools. This allows flexibility in implementation, including the choice of wavelength, material platform, system scale, processing speed, operating conditions, and cost.

In this talk, we review the motivation for integrated quantum photonics, with a focus on silicon nitride as a representative platform. We discuss the state of the art, current challenges, and recent progress across applications ranging from communications to computing.

ID: 252

Experimental Evaluation of Power-over-Fiber Topologies for IoT Sensor Deployment Over Single-Mode Fiber at 1550 nm

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Power-over-fiber (PoF) is a technology that enables the delivery of electrical power through optical fiber by transmitting energy in the form of optical signals. Optical-fiber-based power transmission offers several advantages, including low attenuation over long distances (approximately 0.3 dB/km) and immunity to electromagnetic interference.

This technology is particularly suitable for Internet of Things (IoT) applications, where sensors are often deployed in hard-to-reach locations or in environments with strong electromagnetic interference. In such scenarios, PoF can provide a secure, efficient, and stable power delivery solution.

This work presents an experimental comparison of two fiber-optic power distribution topologies. The first topology employs four independent LASER sources to drive individual photodiode circuits. The second topology uses a single LASER source coupled to a 1:4 single-mode optical power splitter. Both systems were calibrated by adjusting the LASER output powers to achieve a target optical power of −3 dBm at each of the four photodiodes while maintaining a power imbalance below 0.5 dB. Under these conditions, the input power to the splitter was measured at +4.3 dBm to compensate for the splitter attenuation of 7.3 dB.

To evaluate system performance, the four photodiode outputs were connected in series for electrical characterization. The splitter-based topology achieved a peak electrical power of 836.6 µW, showing strong agreement with the first topology, which achieved a peak power of 848.4 µW. The experimental results demonstrate that both topologies provide comparable performance.

The splitter-based topology is limited by the maximum output power of the LASER source and by the splitter attenuation. In this work, the LASER source provided a maximum optical power of 10 mW (10 dBm), limiting the maximum optical power delivered to each photodiode to +2.7 dBm after accounting for the 7.3 dB splitter attenuation. However, this topology offers the advantage of requiring only a single LASER source and a single optical fiber up to the splitter.

In contrast, the first topology enables higher optical power delivery to the photodiodes, reaching a maximum combined optical power of 40 mW (16 dBm) using four independent 10 mW LASERs. Nevertheless, this approach requires additional LASER sources and optical fibers.

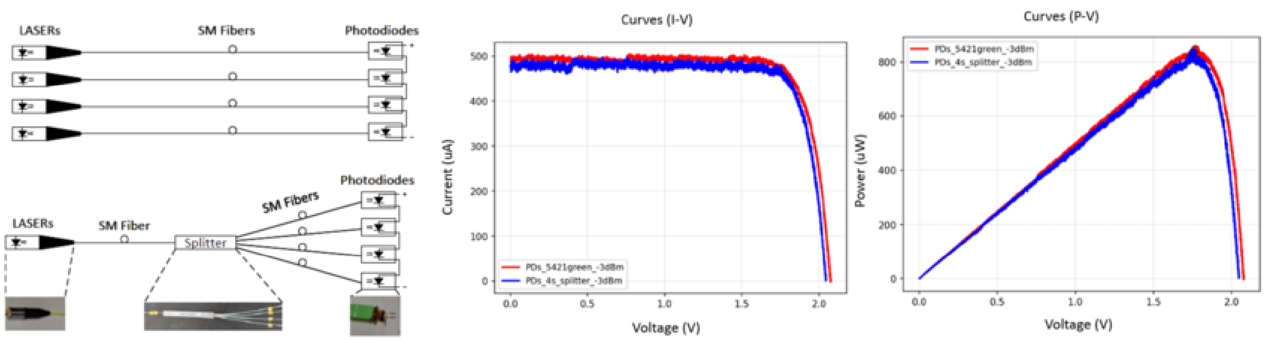

Figure - Four independent Laser vs Splitter 1:4 (left). I-V and P-V Curves (right)

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Silicon Nitride Ring Resonator Simulation for Visible-Band Integrated Photonics

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Integrated optical ring resonators operating in the visible spectrum remain underexplored compared to their near-infrared counterparts, despite growing demand in biosensing and short-range optical communications. Existing photonic platforms are predominantly optimized for telecom wavelengths (1310–1550 nm), leaving a gap in the design and characterization of resonant structures targeting the 600–700 nm window (Shenlei Bao, 2026). Silicon nitride (Si3N4) photonics is experiencing growth due to its broad optical band, enabling applications ranging from visible to mid-infrared in areas such as biophotonics, telecommunications, and sensors (Pascual Muñoz, 2017).

This work presents the simulation and geometric optimization of a silicon nitride ring resonator designed for resonance at 650 nm, implemented in an add-drop configuration using RSoft CAD/FullWAVE. Si3N4 was selected for its low propagation loss in the visible range, Chauhan et al. demonstrated losses as low as 0.03 dB/cm at 698 nm in high-confinement Si3N4 waveguides for atomic clock applications and its broad transparency window spanning the visible spectrum (N. Chauhan, 2020).

The geometric parameters, ring radius, waveguide width, and gap distance between the ring and the bus waveguides were dimensioned from the resonance condition and iteratively optimized to maximize power coupling efficiency while suppressing higher-order modes. FDTD-based full-wave analysis was used to validate the spectral response at both the through and drop ports.

Simulation results confirm resonant behavior centered at 650 nm, with a projected quality factor (Q-factor) on the order of 103–104, finesse exceeding 50, and a 3 dB bandwidth below 5 nm, demonstrating high wavelength selectivity. The principal contribution of this work is a validated design methodology for Si3N4 add-drop resonators in the visible band, including a systematic coupling gap optimization not previously reported for this wavelength range. As an extension, cascaded multi-ring architectures with incrementally varied radii are proposed to enable visible-band wavelength-division multiplexing (WDM), analogous to DWDM systems demonstrated in the infrared.

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ID: 254

Sensing Batteries via Optical Fiber Sensors: Operando Monitoring in-cell Refractive Index and Temperature

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Battery systems are essential for mitigating climate change because they store energy generated from clean, though intermittent, sources such as wind and solar. Within battery systems, the lithium-ion battery (LiB) is the most commonly used and commercialized, given its high energy density when compared to other battery chemistries. However, studies on refractive index (RI) variations during battery cycling are lacking in the literature, despite the importance of this parameter in monitoring battery state of health.

In this work, an optical fiber sensor based on Fabry-Perot (FP) interferometry and fiber Bragg gratings (FBG) is instrumented inside a commercial cylindrical 18650 LiB to monitor interior temperature and RI variations during the instrumented battery functioning. The developed sensor is fabricated by splicing a photosensitive single-mode fiber (PSMF) to a capillary tube section, which was then cleaved to ~50 µm, creating an FP cavity. This tip is then spliced to a multimode fiber section, which is itself then cleaved to ~200 µm, forming a second FP cavity. Finally, an FBG is inscribed in the PSMF section of the designed optical fiber sensor. Through a dedicated FFT analysis of the spectral response, the outer medium RI can be monitored by the ratio of the third and first FFT peaks. The temperature, on the other hand, will be monitored by measuring the wavelength shift of the FBG peak. Through these analysis methods, sensitivities of -5.1 RIU-1 and of 9.81 pm/°C were achieved for the FP cavity and FBG, respectively.

After instrumenting the sensor, the battery is cycled at C/4, and six consecutive cycles are monitored. Sudden temperature peaks at the end of the discharge periods are resolved, with values of ~2.2 °C. Regarding RI, after a mostly constant behaviour during the charge, it decreased rapidly during the rest period and the beginning of the discharge period. This RI variation decreased with cycle number, with a maximum value of ~0.2 RIU in the first cycle. A sharp increase was then observed during the discharge-voltage plateau, after which the RI increased more gradually before the next cycle. This work reveals, for the first time, the RI evolution within a commercial 18650 LiB.

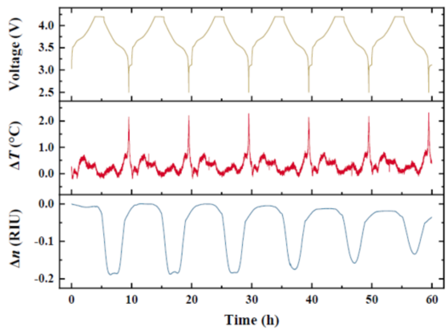

Figure - Temperature and refractive index variations during the LiB cycling at C/4.

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ID: 255

Quantum sensing forever

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Diamond containing optically active color centers, such as nitrogen-vacancy (NV) centers, offer a highly photostable and biocompatible platform for sensing, especially in the form of fluorescent nanodiamonds they offer potential for intracellular temperature measurement with nanoscale spatial resolution. Their robust fluorescence enables long-term imaging without significant photobleaching, making them especially suitable for monitoring dynamic thermal processes inside living cells. We show latest advances on surface functionalization which allows optimized cellular targeting, controlled uptake, and selective localization within specific cellular environments relevant in neuronal signalling [1].

We further present an intracellular temperature readout method not prone to MW heating artefacts, which is achieved through complementary optical and quantum sensing approaches, including fluorescence lifetime measurements. These readout alternatives enable precise, non-invasive monitoring of local thermal changes during therapeutic heating strategies such as magnetic hyperthermia and plasmonic nanoparticle mediated photothermal hyperthermia [2]. By combining targeted nanodiamond thermometry with hyperthermia platforms, intracellular temperature distributions can be tracked in real time, helping to optimize heating efficiency, minimize off-target damage, and improve the safety and precision of thermally activated therapies. Strategy to extend intracellular sensing to 3D disease models using smart 3D scaffolds containing quantum sensors will be presented [3]. The photostability and low blinking characteristics, of NV centers makes them true quantum sensors 'forever'.

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ID: 256

Going Around The Core: Ultra-Sensitive Refractometry Based on Cladding Multimode Interference

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Here, we propose an all-silica balloon shaped fiber sensor for highly sensitive monitoring of the refractive index (RI) in aqueous media. The fabricated sensor is based on a thin-wall silica capillary fiber spliced between two singlemode fibers (SMFs). By adjusting the splicing parameters between the SMF and the capillary fiber, it is possible to control the degree of collapse of the hollow core and fabricate conical-shaped splices obtained from the collapsed silica cladding. In doing so, the input radiation from the SMF is diffracted around the solid conical splice, resulting in the exclusive coupling of the radiation to the cladding of the hollow core fiber, in the form of a multimode interferometer. The close interaction between the cladding radiation and the external media result in notable sensitivity values to variations of RI in liquid media. Due to the known complexity involved in handling inline fiber sensors during RI monitoring, the fabricated structure is then adapted into a balloon shaped configuration.

The proposed device was characterized by its response to RI variations using ethanol solutions ranging from 1-10% (v/v), achieving a baseline sensitivity of 1565 nm/RIU. To evaluate temperature cross-sensitivity, the sensor was characterized by its response to temperature variations in deionized-water and pure ethanol, for which sensitivities of -144 pm/°C and -422 pm/°C were obtained, respectively. These results are directly related to the thermo-optical coefficient of each liquid, which was directly calculated as -9.8×10^{-5} /°C and -2.76×10^{-4} /°C, for water and ethanol, respectively. The complex multimodal interference may be demodulated by means of an inverse Fourier transform at the dominant frequencies of the spectra, which are related to the effective RI differences between the interfering modes. Filtering the lower frequencies resulted in a RI sensitivity of 4103 nm/RIU, and sensitivities of -247 pm/°C and -891 pm/°C, when in water and ethanol solutions, respectively.

The ultra-high sensitivity of the proposed sensor represents significant advantages in comparison to commonly employed multimode-based interferometers. When factoring in the low fabrication cost and robust mechanical strength obtained from the collapsed splices, this structure stands as a promising tool for assisting research on the optical properties of liquid media.

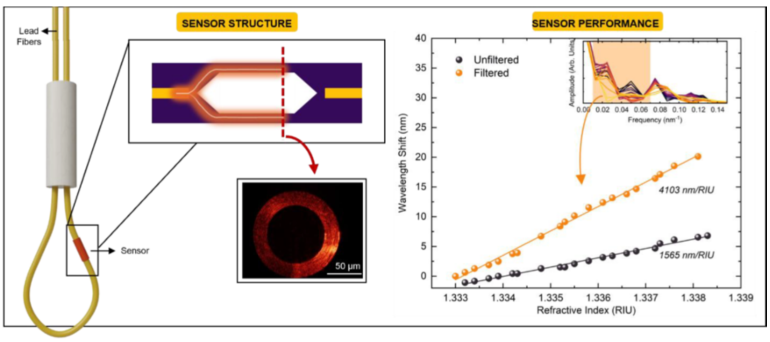

Figure - On the left, illustrative diagram of the sensing configuration, using conical-shaped splices between a capillary fiber and a SMF, in a balloon configuration. The transversal micrograph of the sensor when injected with radiation is also shown. On the right, the sensor response to changes in RI, obtained from the unfiltered and filtered spectra at lower frequencies of their Fourier transform (shown in the inset).

ID: 257

Quantum-based polarization imaging: from quantum to nonlinear interference

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Quantum imaging technologies exploit non-classical correlations, interference, and induced coherence to access information that is difficult or impossible to retrieve with conventional optical systems. Beyond improving sensitivity or enabling low-light operation, these approaches can provide alternative routes to polarization imaging, particularly for birefringent samples whose properties are weak, spatially varying, or nearly transparent.

Within this framework, this work explores two distinct approaches to polarization imaging exploiting quantum properties. First, we utilize quantum wave interference and implement a Hong-Ou-Mandel (HOM) microscopy setup using a single-photon source to probe birefringence, an application still largely unexplored for this technique. The system exploits bosonic photon bunching at a 50:50 beam splitter, monitored through coincidence detection. By leveraging the polarization degree of freedom and the large coherence length of our single photons, we selectively probe birefringent sample properties, showing some proof-of-concept results that demonstrate the viability of this approach with specific quantum advantages.

In a second approach, we are now extending Quantum imaging with undetected photons (QIUP) to polarization imaging, exploiting nonlinear interference and in specific induced coherence without induced emission. In QIUP, idler photons from two spatially separated sources are made indistinguishable, enabling imaging at infrared (IR) wavelengths while detection occurs in the visible range, avoiding complex IR detectors and emitters. We are establishing a baseline QIUP system to study its sensitivity to birefringence and polarizing materials, with the longer-term goal of performing microplastic analysis in a microfluidic platform.

Together, these efforts represent meaningful progress towards precise, alternative polarization quantum sensors, with QIUP emerging as a strong candidate for quantum imaging beyond highly specialized settings.

ID: 258

All-optical coherent quantum control for quantum-enhanced photonic sensing

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Quantum-enhanced optical measurement requires not only non-classical states of light, but also coherent control over the dynamical quantum noise processes that limit precision. A prominent example is quantum back-action noise, which arises when the optical probe field perturbs the measured system and thereby limits continuous high-precision sensing.

In this contribution, I present the experimental realisation of an all-optical effective negative-mass oscillator for coherent quantum noise cancellation. The system implements the optical analogue of an optomechanical interaction using cascaded nonlinear optical processes, combining down-conversion and beam-splitting interactions in a compact tabletop platform. An in-situ characterisation method was developed to determine the relevant coupling rates, detunings, linewidths and quadrature angles under operating conditions.

Based on the experimentally characterised system, the realised platform projects broadband quantum noise reduction of 3.6 dB, corresponding to a 77% reduction of quantum back-action noise at the optimal frequency. Beyond this specific implementation, the result illustrates how engineered nonlinear optical interactions can be used as programmable auxiliary systems for quantum-enhanced sensing.

I will discuss this experiment as one example of engineered nonlinear optical dynamics for quantum-enhanced sensing, and briefly outline how related concepts may connect to future work on multimode squeezed-light generation, phase-sensitive optical readout and frequency-multiplexed quantum optical systems.

ID: 259

Optimization of Lens Design for Spot Size Stability Under Irregular Surface Topologies

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Optical systems used in direct laser lithography are highly sensitive to variations in the effective working distance caused by non-uniform target surface topography. Local height variations in the material introduce small focal shifts during exposure, resulting in changes in spot size due to defocus, aberrations, and diffraction effects. These effects are particularly problematic in direct-write laser applications.

This article addresses variations in spot size through simulation-based lens design and optimization studies conducted in ZEMAX OpticStudio. The primary objective is to minimize spot size variation across a defined range of focal lengths while maintaining robust optical performance in the presence of surface and alignment imperfections. A baseline optical system is first developed and parameterized to enable systematic adjustment of key design variables. Ray tracing and wavefront analysis are then used to evaluate optical performance across multiple configurations. A multi-configuration optimization framework is subsequently applied to identify designs that minimize variation in modulation transfer function (MTF), spot size, and aberration behaviour over the typical operating range.

To enhance robustness, the optimization explores lens curvature distributions, inter-element spacing, and aperture constraints. Tolerance analysis is performed to assess sensitivity to small perturbations in lens position and surface curvature, enabling identification of configurations with stable optical performance.

The results show that optimized lens architectures significantly reduce spot size variations induced by small defocus errors arising from non-uniform target surface topography, thereby improving imaging stability during laser exposure. Which yields more consistent resolution under realistic working distance variations introduced by surface height irregularities.

ID: 260

Graphene Based Modulator

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The rapid growth of artificial intelligence (AI), cloud computing, and large-scale data centres has increased the demand for optical communication systems capable of supporting ultra-high data transmission rates with low energy consumption. Conventional optical modulators used in integrated photonic systems often suffer from limitations such as high power consumption, restricted bandwidth, and large device footprints, reducing their suitability for next-generation Tbit/s optical interconnects and energy-efficient computing applications. These challenges have motivated the exploration of alternative materials and device architectures capable of delivering high-speed performance, compact integration, and improved energy efficiency.

Graphene presents a promising solution due to its exceptional electrical and optical properties, including ultra-high carrier mobility, broadband optical absorption, tuneable conductivity, and compatibility with silicon photonics. This article proposes a graphene-based electro-absorption optical modulator integrated on silicon for high-speed and low-power optical communication applications.

The methodology of this study is based on theoretical analysis and simulations to investigate the electro-optic behaviour and performance of the proposed device. Electromagnetic simulations will be conducted to analyse the interaction between graphene and the optical waveguide, while theoretical modelling will be used to evaluate carrier transport, optical absorption, and modulation characteristics under varying bias conditions. Key performance parameters, including modulation bandwidth, extinction ratio, modulation efficiency, insertion loss, and energy consumption, will be analysed to assess the feasibility and efficiency of the proposed modulator design.

This study aims to demonstrate the potential of graphene-integrated silicon photonics for future high-speed, compact, and energy-efficient optical communication systems suitable for AI-driven and data-intensive applications.

ID: 261

Nd:YAG Pulsed Laser Deposition Platform for Thin-Film and Nanostructured Material Fabrication for Photonic Applications

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A pulsed laser deposition (PLD) platform based on a Q-switched Nd:YAG laser has been developed for the fabrication of thin films and nanostructured materials for photonic applications. The objective of this work is the implementation of a flexible deposition system enabling controlled growth of optical-functional materials.

A Q-switched Nd:YAG laser with a repetition rate of 20 Hz, a pulse duration of approximately 6 ms, and a pulse energy up to 800 mJ at the fundamental wavelength (1064 nm) is used. Other than the fundamental wavelength, the second or fourth harmonics (532 and 266 nm) can be selected using ad-on harmonic generators. The material deposition on the temperature-controlled substrate is achieved by laser ablation on a specific target inside a vacuum vessel. The laser beam with a diameter of approximately 10mm can be focused on the target using an inside-chamber converging lens, thus increasing the fluence.

Depositions were performed over a glass subtract, by sublimation of molybdenum (Mo), aluminum (Al), chromium (Cr) and nickel oxide (NiO) targets. Experimental studies were conducted to evaluate the influence of key parameters such as laser wavelength, laser fluence in target, chamber pressure, substrate temperature and distance between target and substrate. The effects of these variations were correlated to thin film properties including surface coverage, uniformity, and qualitative morphological changes, enabling the optimization of deposition parameters.

ID: 262

Hierarchical Classification of Polymer Pellets using Short-Wave Infrared Hyperspectral Imaging for Recycling Applications

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The long term objective of this work is to deploy an automated plastic waste identification system in a plastic recycling factory, positioned between silo storage and the extruder. As a first step, this study tests the approach in a controlled laboratory setting with pure plastic pellets, to establish whether the six target polymers can be reliably discriminated before further adaptation to the production line. Among commodity plastics, the HDPE/LDPE pair is the most difficult to separate spectrally, sharing the same polymerized ethylene backbone and differing only in chain branching density and crystallinity.

The system combines hyperspectral imaging in the short wave infrared range(SWIR, 900-1700 nm) with artificial intelligence techniques to identify the six types of polymers: ABS, HDPE, LDPE, PA6, PET, and PP. Each captured session contains a random number of pellets, individually segmented by a foundational model, the mean spectrum of each pellet is then normalized and transformed into the 1st and 2nd derivatives to amplify the discriminating signal. Discriminative intervals are identified per classification node by Cohen's-D effect analysis, following a triple partitioning protocol that isolates discovery, validation and test phases. Classification is performed by a hierarchy of five binary decision nodes, each corresponding to a chemically grounded separation, with probabilistic calibration and a per-node cascade abstention mechanism.

On a held out session with n = 229 pellets the system reaches 100% accuracy and in a leave out session with cross validation and over 2385 pellets across five sessions it carries an excellent 98% accuracy with 1.8% abstention. The HDPE/LDPE pair is supported by a discriminative spectral region at 1503-1556 nm overlapping the 1547nm C-H second overtone band assigned to polyethylene by Bonifazi et al. (2018) and is independently replicated on a second camera to validate the claim. The results of this study establish laboratory feasibility and defines the next step which is validating the same pipeline or adapting it to industrial conditions(contamination, illumination, throughput) before deployment with a separating mechanism between silo storage and the extruder.

ID: 263

Photonic integrated circuit for Salmonella species determination

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There are approximately 2400 serotypes of Salmonella spp, all pathogenic, founded in contaminated foods and water. In some cases, can lead to a more serious infection constituting a serious public health problem. To better understand this microorganism, it has become essential to develop detection techniques.

The proposed solution consists of a photonic integrated circuit (PIC) for the detection of Salmonella spp present in stool samples mixed with saline solution[1], using directional couplers functionalized with antibodies for the detection of Salmonella spp, such as somatic antigens (O), flagellar antigens (H) and capsular antigens (Vi), to determine the presence of Salmonella spp.

The Photonic integrated circuit was simulated using the Rsoft software, utilizing the Beam Propagation Method (BPM) and FemSim. It was considered a SOI (Silicon-On-Insulator) platform with a layer of silicon and a layer of insulator silicon dioxide with a refractive index approximately 3.47 and 1.44, respectively. For this PIC, directional couplers were used as the main components, where the interaction between the microorganism and antigens occured. This PIC workflow was organized into steps, following the Kauffmann-White scheme, the standard international system used by biochemical laboratories to classify Salmonella spp.[2] The optimization of the ideal parameters for the circuit components were done taking into account the SOI platform and Directional Couplers as circuit base components. For testing purposes, a refractive index corresponding to the interaction between bacteria and antigens was assigned.

This work aims to analyse a photonic biosensor for the detection and quantification of Salmonella spp and its subsequent processing for lithography.

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ID: 264

Photonic Interfaces for Weak Dynamics in Nature

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Advanced photonic systems can access, amplify, and interrogate weak physical and biological phenomena that are otherwise difficult to observe. This talk will begin with our newly developed waveguide platform designed for efficient light–matter interactions. Building on this foundation, I will present examples spanning optical biosensing and cell mechanics, highlighting how photonic technologies can reveal weak biochemical and biomechanical dynamics with high sensitivity, speed, and precision. The presentation will emphasize the emerging role of integrated photonics as a universal interface for sensing and understanding complex natural systems.

ID: 265

End-to-End Visible Light Communication Vehicular Prototype: Design and Experimental Validation

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The increasing congestion of the radio frequency spectrum and the growing demand for secure, low-latency communication are limiting the evolution of intelligent mobility and autonomous driving systems. In this context, Visible Light Communication (VLC) emerges as a promising alternative capable of addressing spectrum scarcity in vehicular environments.

This work presents the design and experimental validation of an end-to-end Visible Light Communication (VLC) system, implemented as a laboratory-scale vehicular communication testbed for intelligent mobility applications. The proposed system integrates a complete optical wireless communication link, comprising a transmitter circuit that converts digital electrical signals into optical pulses through LED modulation. At the receiver side, a photodiode captures light variations and converts them into electrical signals, which are further processed using a transimpedance amplifier and filtering stages.

Experimental tests were conducted using different LEDs to evaluate maximum line-ofsight transmission range, angular sensitivity, and system robustness under misalignment conditions. In addition, the signal control strategy was adapted from a theoretical FPGAbased approach to a practical implementation using ESP32-C3 microcontrollers, improving cost efficiency and system integration. The results demonstrate stable communication performance under angular deviations of up to 40 degrees, with one LED configuration exhibiting superior signal stability and being selected for system integration.

Overall, the experimental validation confirms that the proposed VLC vehicular testbed provides a robust and stable end-to-end optical wireless communication link under realistic alignment and distance variations. These results highlight its suitability as a scalable platform for future optical vehicular communication systems and intelligent transportation testbeds.

ID: 266

Introducing Dual-Cell Photoacoustic Spectroscopy for Studying Quantitative Absorption Spectrum Of Aerosols

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This study investigates the quantitative absorption properties of aerosols using a mid-infrared laser system (3300–3550 nm) in a novel dual-cell photoacoustic (PA) setup. The setup consists of two series-connected cells with identical geometry: one cell contains propane gas as a reference, while the second cell houses propylene aerosols. Both cells are equipped with sensitive microphones for precise detection of the PA signal, allowing for an in-depth analysis of aerosol absorption characteristics. The dual-cell configuration enhances measurement accuracy by providing a reference for signal comparison, improving the reliability of PA spectroscopy in assessing the absorption properties of aerosols. This approach offers an effective method for studying light-matter interactions and optical properties in aerosols, facilitating a more robust analysis of the quantitative absorption spectra of the analyte.

ID: 269

Outdoor Evaluation of Low-Resolution LiDAR Representations for Assistive Obstacle Detection

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Predicting how low-resolution spatial representations behave in real-world environments is essential for designing reliable Electronic Travel Aids for visually impaired individuals. In these systems, reducing spatial information while preserving relevant obstacle cues may help support clearer and more manageable user feedback.

This work presents an ongoing empirical study using a reconfigurable pan-tilt LiDAR scanning platform to evaluate low-resolution obstacle representations in an outdoor environment. The study will also apply the same experimental path to the VL53L5CX, a native 8 by 8 solid-state time-of-flight matrix sensor, enabling comparison between simulated low-resolution representations and hardware-native acquisitions.

The methodology involves a 9-meter outdoor path containing four static obstacles of varying dimensions, evaluated under late afternoon and early evening lighting conditions. Using a fixed platform height of 1.70 meters, sequential 40 by 40 scans with 1-degree angular steps were acquired at 1-meter intervals along the path, with each scan requiring approximately 2 minutes and 45 seconds. The high-density scans were reduced using mean-pooling and min-pooling strategies to simulate low-resolution representations.

The outdoor course results showed that mean-pooling introduced relevant information loss and distance estimation errors due to spatial averaging over complex obstacle geometries. In contrast, min-pooling preserved all obstacle regions by retaining the closest measured point within each downsampled cell.

Current results indicate that minimum-based reduction preserves obstacle regions more effectively than mean-based reduction, suggesting a more conservative strategy for safety-oriented obstacle detection. This provides a practical baseline for subsequent validation against native 8 by 8 sensor data, allowing assessment of how closely hardware-native acquisitions reproduce the simulated low-resolution representations.

ID: 270

Microfluidics model to analyze formation of intracranial aneurysm: fabrication challenges with optical technologies

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In recent years, the field of microfluidics has experienced significant growth due to the reduced volume of samples required for analysis, as well as the ability to create devices that simulate tissues and organs, thereby reducing the need for animal testing. These Lab-on-a-Chip devices are particularly useful in the study of vascular diseases. This work presents the fabrication, using optical technologies, of a microfluidic system that allows for the simulation and analysis of the hemodynamic environment associated with aneurysm formation. The flow conditions necessary to generate sufficient shear stress on the vessel wall to cause endothelial dysfunction in the channel are determined through simulation. The results of the actual flow over the cells seeded in the channel will be presented. Finally, the challenges to be addressed in the fabrication of in vitro blood vessels based on a combination of optical technologies and materials will be analyzed.

ID: 271

Laser processing of oxides for energy applications

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Oxide materials offer immense versatility in tuning electrical, magnetic, optical, and thermal properties through chemical substitution and precise processing control. This work discusses the potential of laser-based technology for the synthesis of advanced oxide materials, specifically focusing on the Laser Floating Zone (LFZ) technique. LFZ enables the production of fully dense, high-purity crystalline fibres, offering unique advantages such as the formation of metastable phases and the control of ionic oxidation states by adjusting growth atmospheres, pulling rates, and applying external fields (electric or magnetic). Demonstrating that the interplay between growth parameters and thermal gradients, allows for the fine-tuning of microstructure and phase composition, directly impacting functional performance. This study explores the correlation between these structural modifications and the resulting physical properties. By defining optimized growth and post-processing re-equilibration conditions, we provide guidelines for the development of tailored materials. Finally, we highlight the suitability of LFZ for processing oxides aimed at two major frontiers: energy applications, such as high-efficiency thermoelectric energy conversion, and advanced electronic devices, where precise control over charge carrier mobility and structural defects is essential for sensor and other applications.

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ID: 272

Laser technology in the injection moulds industry

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Examples of using lasers technology to clean moulds could be found, such as a CO2 laser to clean the moulds in the glass industry or the laser fibre in the elastomers industry. The major difficulties to implement such technology is when the mould surface and the residues interact in the same manner with the laser beam used. A study of the implementation of the laser technology to clean a metallic mould according with the type of polymer injection and coating were addressed. The residues are from different types of polymers and can be removed by ablation, using a fibre laser. However, this radiation is also highly absorbed by the mould surface and its coating, been a challenge. The optimization of the laser parameters such as power, frequency, scan speed, etc, is required for efficient residues removal according with the types of polymers,without the degradation of the mould surface and coatings. The present study report the optimization of laser parameters according with the polymers specification and the existence or not of coatings at the mould surface. The results obtained show the efficiency of laser technology in cleaning these moulds on each polymer and surface (coated or not). Moreover, also show the need of laser parameters specifications according with the polymers types and surface used.

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ID: 273

Development and operation of laser spectroscopy of lanthanides at KU Leuven

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Laser resonance ionization spectroscopy is a powerful technique for extracting nuclear properties such as nuclear spins, magnetic dipole and electric quadrupole moments, and changes in nuclear charge radii through the measurement of hyperfine structures and isotope shifts. Lanthanide elements remain particularly challenging due to their complex electronic configurations, dense atomic spectra, and low ionization potentials, which complicate the development of efficient and selective laser ionization schemes.

To address these challenges, a new laser spectroscopy setup is being developed at KU Leuven for resonance ionization studies of lanthanides using the Atomic Beam Unit (ABU). The setup is designed for offline spectroscopy of stable and long-lived isotopes, enabling the optimization of laser ionization schemes before online experiments with radioactive isotopes. The combination of dye lasers and Ti: sapphire lasers with intracavity frequency doubling significantly expands the accessible excitation pathways and wavelength coverage.

In this work, we report laser spectroscopy measurements of 169Tm in ABU. Several laser excitation schemes were investigated and optimized, leading to the identification of a new autoionizing state in thulium. The observed spectroscopic transitions and ionization efficiencies demonstrate the suitability of the setup for high-resolution resonance ionization spectroscopy of lanthanides. These results provide an important reference for future in-source laser spectroscopy studies of radioactive rare-earth isotopes.

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ID: 274

Optimization of Optical Coupling from Free Space to Photonic Waveguides under Alignment and Turbulence Constraints

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This work investigates the optimization of optical coupling between free-space propagation and photonic waveguides, addressing two complementary scenarios: coupling into integrated photonic circuits and coupling of telescope-collected light into optical fibers in free-space communication systems.

The study aims to establish a unified framework linking optical system design parameters to coupling efficiency. Particular emphasis is placed on mode matching and the evaluation of coupling efficiency through overlap integrals between the incident optical field and the guided waveguide modes.

For integrated photonics, the analysis focuses on focusing optics, spot size control, alignment tolerances, and their impact on coupling performance. For free-space optical links, the study considers light collected by a telescope after propagation through a turbulent atmosphere, including the effects of wavefront distortions and the potential use of adaptive optics elements such as fast steering mirrors or deformable mirrors.

The methodology combines optical system modeling and tolerance analysis with numerical simulations to evaluate coupling efficiency under realistic conditions. Experimental results are used to support and validate the theoretical findings.

This work provides design and optimization guidelines for efficient optical coupling in both integrated photonics and free-space optical communication systems, highlighting the trade-offs between system complexity, robustness, and performance.

ID: 275

Femtosecond Laser Ablation of Flexdym Elastomeric Polymer for Biomedical Surface

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Pulsed laser ablation is a versatile approach for the controlled functionalisation of materials in fields such as biomedicine, tissue engineering and microfluidics. Specifically, femtosecond pulsed laser ablation (fs PLA) enables to process substrates at the micrometric scale with high spatial precision, given the reduced heat-affected regions and minimal debris deposition. This fact is essential for polymeric materials as they are prone to melting under thermal stress.

In this work, we investigate the response of FlexdymTM to fs PLA. This polymer excels by its elastomeric nature with potential relevance in deformable and biomedical systems, and it is considered an alternative to conventional Polydimethylsiloxane (PDMS) in the microfluidic realm.

Laser processing was conducted using the STELA femtosecond laser system at the L2A2 facilities of the University of Santiago de Compostela. The study focused on the identification of the processing windows for this material, including the estimation of its ablation threshold and the fabrication of laser-defined microfeatures such as grooves, grids and pits. These structures were characterised by confocal microscopy and microcomputed tomography in terms of width, depth and cross-section, providing insight into the three-dimensional structural features ofthe samples.

The laser-driven modifications were linked to the thermal transitions and chemical composition of the polymer, aiming to connect material properties with ablation behaviour. Finally, changes in wettability after laser processing were assessed by contact angle measurements.

These wettability modifications are relevant for the use of FlexdymTM as a functional biosurface in microfluidic environments, where surface chemistry, topography and wetting behaviour can influence protein adsorption, cell attachment and bacterial colonisation. Overall, this work provides a femtosecond laser micromachining framework for the functionalisation of FlexdymTM for advanced surface engineering applications.

ID: 276

Laser-based Technologies for the Advanced Fabrication of Organ-on-a-Chip Devices in Personalized Medicine

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The significant gap between initial drug discovery data and actual clinical results stems largely from discrepancies between conventional in vitro cellular experiments and preclinical in vivo assays. To bridge this gap, Organ-on-a-Chip (OoC) technology has emerged, offering microfluidic platforms that mimic physiological environments where cells can exhibit natural responses. However, traditional manufacturing methods like photolithography and reactive ion etching (RIE) are often limited by high costs, complex protocols, and the restriction to 2D surface structuring.

This work highlights the pivotal role of optical technologies in overcoming these limitations, focusing on the integration of laser systems for the development of precise and reliable OoC devices. Stereolithography (SLA)nhas revolutionized the field by enabling the direct, layer-by-layer fabrication of complex 3D structures, including internal microchannels and pillars, with high accuracy and biocompatibility. Complementing this, Pulsed Laser Ablation (PLA) offers a non-contact, high-speed, and versatile method for micrometer-scale surface patterning on various substrates, such as polymers and glass.

As an example, the application of these laser-based technologies is used to fabricate specialized platforms for studying circulating tumor cells (CTC) in metastatic models. These advancements not only democratize access to sophisticated microfabrication but also represent a fundamental step toward the realization of truly personalized therapies and the reduction of animal testing in biomedical research.

ID: 278

Multiwavelength Photoacoustic Spectroscopy for Emission-Based Fuel Development.

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For emission-based fuel development, we measured the absorption of diesel exhaust particulate matter using a multiwavelength photoacoustic system with lasers ranging from the near-infrared to the ultraviolet range. We also measured the electrical mobility size of the particles. Additionally, we performed the measurements at two different volatility temperatures (i.e., 40°C and 250°C). We compared two different candidate fuels and calculated their organic and elemental carbon ratios in the exhaust particulate matter

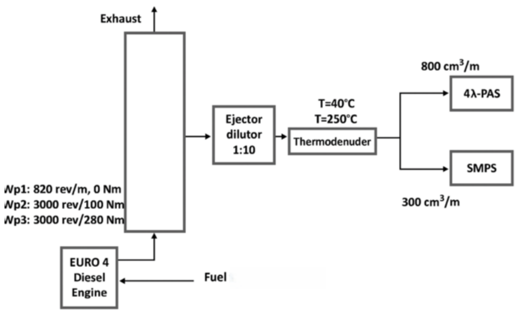

Figure - Schemetic diagram of the setup.

ID: 279

Analytical Technique for the Quantification of C2H4 and CH4

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Introduction

The detection of trace-level molecules is crucial in medicine, industry, agriculture, and environmental monitoring. In medicine, gaseous biomarkers in human breath enable non-invasive diagnostics. In industry, toxic and greenhouse gases require strict monitoring to protect public health and the environment. In agriculture, molecules such as ethylene (C2H4) indicate fruit ripening, while greenhouse gases like methane (CH4) are monitored to control environmental impacts [1, 2].

Photoacoustic spectroscopy (PAS) stands out as a technique for the qualitative and quantitative detection of these gases. The photoacoustic effect occurs when the absorption of modulated radiation by a molecule generates an acoustic signal. If the absorption is not saturated, the signal is proportional to the absorbing species's concentration. PAS is sensitive, selective, non-destructive, and allows continuous monitoring at parts-per-billion (ppb) to parts-per-trillion (ppt) levels, outperforming gas chromatography (GC) in this analytical aspect [3].

Objectives

To characterize a photoacoustic sensor capable of detecting and quantifying both methane and ethylene.

Materials and Methods

For the detection and quantification of methane and ethylene, a photoacoustic sensor has been developed. It consists of a DFB laser (Nanoplus) with center emissions in 3351 nm and a differential photoacoustic cell (DPC) fabricated using 3D printing. The laser is controlled by a temperature controller (Thorlabs - TTC001) and a current controller (Thorlabs - KLD101). The system also includes a power meter (Thorlabs - PM4000), function generator (WON – AG1022) for the laser modulation and a lock-in amplifier (Signal Recovery - 7265) to demodulate and filter the signal. As a first approach, measurements were performed under a static chamber regime, closing the cell with a directional valve (Swagelok) following gas injection. The analyzed samples consist of methane and ethylene, diluted in nitrogen, at concentrations up to 10 ppm.

Results

We will present the initial measurements comprising the determination of the photoacoustic sensor's calibration curve as well as its detection limit.

Future perspectives include automating the injection process and integrating this photoacoustic system with gas chromatography.

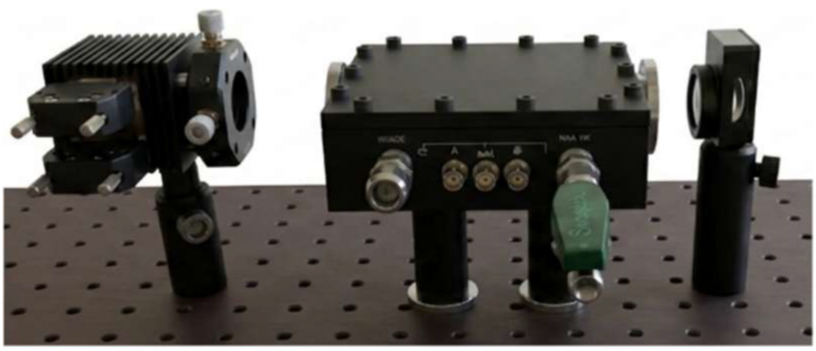

Figure - DFB Laser, photoacoustic cell, power meter.

ID: 280

Photonic Computing & Applications

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Artificial intelligence and combinatorial optimization problems—such as drug discovery and prime factorization—remain challenging even for advanced computers. We are attempting to address these limitations by building photonic processors inspired by the brain—photonic neural networks—which utilize light for faster and more energy-efficient processing. We will discuss photonic networks, including Ising machines enabled by thin-film lithium niobate photonics, highlighting their applications in number partitioning, protein folding, wireless communications, and deep learning. Time permitting, we will briefly introduce a quantum photonic neural network that can learn to act as near-perfect components of quantum technologies and discuss the role of weak nonlinearities.

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ID: 281

The Rise of Sustainable Advanced Materials for Electronics and Energy Applications

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The rapid socio-economic growth driven by the rising demand for smart electronics, energy harvesters, and plastic-based products—coupled with our reliance on non-recyclable raw materials—has intensified climate change and disrupted ecological balance, depleting our natural resources. As we advance in this technological revolution, the rise of the Internet of Things (IoT) and wearable devices further complicates these issues, highlighting the need for high-resolution communication interfaces.

This evolution necessitates a critical shift towards green technologies focused on environmental sustainability, particularly in materials beyond silicon. Emerging nanoscale devices present promising alternatives that exceed traditional silicon solutions, paving the way for eco-sustainable innovations. Notably, transparent and paper electronics have the potential to transform electronic device design.

This presentation will explore pathways to address these interconnected challenges by minimizing electronic waste (e-waste) while advancing sustainable technological solutions. We are committed to developing eco-friendly green electronics and energy harvesters that meet consumer needs and adhere to environmental stewardship principles.

Additionally, we aim to raise social awareness about sustainable technologies. By engaging with communities, businesses, and policymakers, we seek to promote practices that can revolutionize industry and society. Through innovative business models and advocacy for sustainable lifestyles, we envision a future where technology harmonizes with environmental responsibility, fostering a sustainable world for generations to come.

We invite you to join us in exploring strategies to tackle these urgent challenges and champion the transition to a more sustainable future. Together, we can significantly impact our environment and society, building a resilient world supported by green technology.

ID: 282

Photoanisotropy in a Non-Azobenzene Composition with an Extended Operating Range

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Photoanisotropic materials based on azobenzenes are widely used for polarization holography and optical data storage due to their high sensitivity to polarized light and long-term stability. However, azobenzene media exhibit strong absorption in the shortwave visible region, limiting their effective operation below approximately 500 nm.

In this work, we investigate the possibility of extending the operational spectral range of polarization-sensitive materials toward the near-ultraviolet region by replacing the azo (-N=N-) chromophore with a stilbene (-CH=CH-) fragment. Hydrophilic stilbene compositions based on 4,4'-diamino-2,2'-stilbenedisulfonic acid incorporated into photogelatin films were experimentally studied.

Photoanisotropy was induced using linearly polarized ultraviolet radiation at 375 nm and characterized through effective anisotropy measurements, allowing real-time monitoring of photoanisotropy kinetics. The induced birefringence was probed at 445 nm, 532 nm, and 635 nm using a custom photometric setup developed for multiwavelength investigation of polarization-sensitive media.

The experiments confirmed the possibility of inducing photoanisotropy in stilbene-based media transparent in the visible spectral range. Unlike conventional azobenzene materials, the investigated compositions demonstrated operation in the 475–400 nm region, which is typically inaccessible for azobenzene systems. Multiwavelength probing revealed wavelength-dependent differences in the induced response, indicating a nontrivial spectral behavior of the recorded anisotropy.

At the same time, the achieved photoanisotropy levels remained relatively low due to competing photoluminescence processes observed under ultraviolet excitation. The obtained results experimentally validate stilbene derivatives as promising non-azobenzene candidates for ultraviolet-sensitive polarization materials with extended spectral operating range.

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3D printing of optical interconnects for PICs

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Quantum X align supports the fabrication of precisely aligned 3D micro-optics directly on photonic integrated circuits, optical fibers, fiber arrays, and chip facets. For PIC, optics, and photonics applications, this enables compact and efficient optical interfaces such as microlenses, fiber-to-chip couplers, beam-shaping elements, and freeform optical components. By combining high-resolution 3D printing with automated alignment, Quantum X align helps reduce coupling losses, simplify photonic packaging, and improve design flexibility. This makes it a valuable platform for advancing photonic systems used in optical communications, sensing, quantum technologies, and integrated optical devices.

A live demonstration via a remote connection showcases how the precise fabrication of scalable coupling structures is enabled.

ID: 285

Analytical Modeling And Control Of Nonlinear Light–Matter Interactions In Ultracold Quantum Systems

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Understanding and controlling nonlinear light-matter interactions in ultracold quantum systems is essential for emerging quantum technologies. We present an analytical framework to describe and control atom-molecule conversion in ultracold atomic gases driven by laser fields. Coherent photoassociation dynamics in Bose-Einstein condensates are modeled using nonlinear mean-field equations that include inner-particle interactions.

We develop an analytical approach based on adiabatic tracking of nonlinear quantum dynamics, enabling robust population transfer from an atomic condensate to a molecular state. The method provides explicit relations between laser parameters-such as Rabi frequency, detuning, and the resulting population dynamics, allowing identification of optimal configurations that avoid separatrix crossing and ensure efficient conversion. The analysis is further extended to include Kerr nonlinearities and stimulated Raman processes, demonstrating robust transfer even in the presence of nonlinear interactions and dissipation.

We also investigate analytically solvable two- and three-state models for time-dependent level-crossing processes. Solutions are expressed using special functions, providing deeper insight into nonlinear light–matter dynamics. These results offer theoretical tools for coherent molecular formation, quantum control, and photonic quantum technologies.

Keywords: Nonlinear light-matter interaction, Bose-Einstein condensates, Coherent photoassociation, Adiabatic control, Ultracold atomic systems, Quantum technologies, etc.