SCHOOL IN BIOPHOTONICS, AI AND DATA ANALYSIS 9-13 JUNE 2025, ALGHERO, ITALY

PROGRAMME

We are thrilled to welcome you to the ***Summer School on Biophotonics, AI and Data analysis,*** organized within the framework of the Cost Action CA23125 - The mETamaterial foRmalism approach to recognize cAncer (TETRA), an exceptional opportunity to enhance your research skills, share your work, and engage with leading experts — all in the breathtaking setting of Alghero, Sardinia.

Chair

Francesco Saverio Pavone, Department of Physics and Astronomy, University of Florence, Italy

Programme Committee

Victoria Barygina, Department of Physics and Astronomy, University of Florence, Italy
Roberto Inchingolo, European Laboratory for Non-linear Spectroscopy, Italy

For more information, please contact:

Prof Tatjana Gric, Action Chair, tatjana.gric@vilniustech.lt

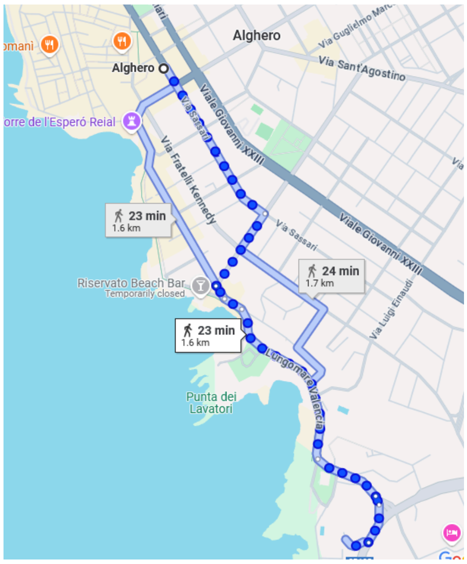
Victoria Barygina, Science Communication Coordinator, victoria.barygina@unifi.it

LOGISTICS INFORMATION

The Summer School will take place in Alghero, Sardinia, at the Hotel Calabona.

Getting to Alghero

- Alghero has a small airport where you can land your connecting flight from major Italian airports such as Rome and Milan, as well as infrequent international flights.
- The other two airports in Sardinia (Olbia and Cagliari) are also reached by international flights, but a long transfer by train will be necessary to reach Alghero.
- More information about Sardinians airports, routes and companies can be found here.
- The city centre is 20 min taxi transfer away from the airport.
- The school venue can also organise a shuttle transfer for you.



Getting to the School Venue

- Hotel Calabona is on the Southern coast of Alghero, 30 min walk from the old port in the city centre.
- Viale della Resistenza is also served by public transport that reaches the city centre in 10 - 15 min.
- There is a free shuttle service to the Hotel from 12.30 to 15.30 and to 18.30 to 23.30.

Hotels

- There are many hotels in the City Centre and on the Southern coast, close to the venue.
- Alghero is a major tourist destination so we recommend you book your accommodation as soon as possible.
- The preferred option is to stay at Hotel Calabona itself, which offers an early bird option for school participants. Hotel guests will also be able to use its pool and private beach.
- Hotel Calabona offers daily shuttle services for people who need to reach their hotel in the city center.

Food

- A lunch and two coffee breaks will be provided every day to all school participants.
- Like most hotels in the city, Hotel Calabona has its own restaurant where you can have your dinner, and a restaurant in the city center (La Lepanto).
- A social dinner at La Lepanto is scheduled for the first night at 20PM. Kindly be aware that the cost of the social dinner is not covered and should be paid individually by each participant.
- The city centre offers many venues for food and drinks.

SCHOOL SCHEDULE

<table>
<tr><th></th><th>09.06.2025</th><th>10.06.2025</th><th>11.06.2025</th><th>12.06.2025</th><th>13.06.2025</th></tr>
<tr><td>10.00-11.00</td><td>Registration</td><td>Giannis Zacharakis</td><td>Edik Rafailov</td><td>Pablo Loza-Alvarez</td><td>Bojan Resan</td></tr>
<tr><td>11.00-11.30</td><td>Opening</td><td>Coffee break</td><td>Coffee break</td><td>Coffee break</td><td>Coffee break</td></tr>
<tr><td>11.30-12.30</td><td>Kirill Larin</td><td rowspan="2">KEYNOTE Paul French</td><td>Victoria Barygina</td><td rowspan="2">KEYNOTE Daniel Razansky</td><td>Tatjana Gric</td></tr>
<tr><td>12.30-13.00</td><td rowspan="3">Lunch break</td><td>Discussions on Photonics Meeting Biology</td><td rowspan="2">Vyacheslav Kalchenko</td></tr>
<tr><td>13.00-13.30</td><td rowspan="2">Lunch break</td><td rowspan="2">Lunch break</td><td rowspan="2">Lunch break</td></tr>
<tr><td>13.30-14.30</td><td>Lunch break</td></tr>
<tr><td>14.30 -15.30</td><td>Grigorii Sokolovskii</td><td>Sergei Sokolovski</td><td rowspan="6">Networking</td><td>Mihaela Žigman</td><td>14.30-15.00 Closing and best poster nomination</td></tr>
<tr><td>15.30-16.00</td><td>Coffee break</td><td>Coffee break</td><td>Coffee break</td><td rowspan="5">15.00-19.00 Managers Meeting (reserved for TETRA Action MC Board)</td></tr>
<tr><td>16:00-17.00</td><td>Igor Meglinski</td><td>Veres Miklós</td><td>Tarek Eissa</td></tr>
<tr><td>17.00-18.00</td><td rowspan="2">Free time</td><td>Poster session</td><td>Poster session</td></tr>
<tr><td>18.00-20.00</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>20.00-22.00</td><td>Networking</td></tr>
</table>

SPEAKER	AFFILIATION	TITLE
KEYNOTE SPEAKERS		
French Paul	Imperial College London & Francis Crick Institute, UK	*An open-source modular approach to research microscopy including machine learning to enhance image data acquisition and analysis*
Razansky Daniel	University of Zurich and Department of Information Technologies and Electrical Engineering, ETH, SW	*Optoacoustic imaging - instrumentation, algorithms, and applications*
INVITED SPEAKERS		
Larin Kirill	Department of Biomedical Engineering, University of Houston, USA	*Optical Coherence Tomography and Elastography*
Loza-Alvarez Pablo	The Institute of Photonic Sciences, SP	*Selected biomedical applications in Light sheet fluorescence microscopy*
Meglinski Igor	Aston University, UK	*Advances in Quantitative Analysis of Blood Flow with Dynamic Light Scattering Imaging*
Rafailov Edik	Aston University, UK	*Photonics as a Tools for Biomedical Applications: Imaging, Diagnostics and Treatments*
Sokolovski Sergei	Aston Institute of Photonic Technologies, Aston University, UK	*Illuminating Life: How Photonics and AI Can Shape the Future of Healthcare*
Miklós Veres	HUN-REN Wigner Research Centre for Physics, HUN	*The use of Raman spectroscopy for DNA detection and tissue characterization*
Zacharakis Giannis	Institute of Electronic Structure and Laser – Foundation for Research and Technology, GRC	*Looking and listening to light inside complex biological systems: extending the limits of microscopic imaging*
Žigman Mihaela	Max Planck Institute of Quantum Optics, GE	*Systems biology aided by optical spectroscopic techniques - New avenues to extend our understanding and capture of cancer*
SELECTED COMMUNICATIONS		
Barygina Victoria	University of Florence, Dep. Physics and Astronomy, IT	*Multispectral optical sensor for monitoring psychological stress*
Eissa Tarek	Ludwig-Maximilians-University of Munich, GE	*Analyzing Vibrational Spectra with Machine Learning: Practical Methods, Tools, and Common Pitfalls*
Gric Tatjana	Vilnius Gediminas Technical University, LT	*A Roadmap from the Perspectives of the Metamaterials Effective Properties and Applications*
Kalchenko Vyacheslav	Weizmann Institute of Science, IL	*Hybrid Local AI for Multimodal Analysis of Bioluminescence and ultra low intensity auto-luminescence Images*
Resan Bojan	University of Applied Sciences and Arts Northwestern Switzerland, SW	*Novel ultrafast lasers for biomedical applications*
Sokolovskii Grigorii	Ioffe Institute, St Petersburg State Electrotechnical University, RU	*Semiconductor lasers: What's next?*

FULL PROGRAMME

Monday 9/6/2025		
10:00- 11:00	**Registration**	
11:00 - 11:30	**Opening - Francesco Pavone**	
11:30 - 12:30	**Lecture**	**Optical Coherence Tomography and Elastography**
	Kirill Larin	Department of Biomedical Engineering, University of Houston, USA
		Kirill Larin is Cullen Endowed Chair and Professor of Biomedical Engineering at the University of Houston. Larin received his first M.S. in Laser Physics and Mathematics from the Saratov State University, Russia, in 1995, his second M.S. in Cellular Physiology and Molecular Biophysics in 2001, and his Ph.D. in Biomedical Engineering in 2002 from the University of Texas Medical Branch. His research contributions are Biomedical Optics and Biophotonics and the development and application of various optical methods for noninvasive and nondestructive imaging and diagnostics of tissues and cells. He made significant contributions to the development of Optical Ealstographjy methods. He is the recipient of the prestigious Presidential Award from Russian President Boris Yeltsin. He was inducted as a Fellow of SPIE in 2015, a Fellow of Optica in 2016, and a Fellow of AIMBE in 2020. He is the 2025 recipient of the SPIE Biophotonics Technology Innovator Award.
12:30 - 14:30	**Lunch break**	
14:30 - 15:30	**Lecture**	**Semiconductor lasers: What's next?**
	Grigorii Sokolovskii	Ioffe Institute, St Petersburg State Electrotechnical University, Russia
		Grigorii S. Sokolovskii received the MSc degree in optical electronics from St. Petersburg State Electrotechnical University (LETI), St. Petersburg, Russia, in 1994, and PhD and Doctor of Science (Habilitation) in physics of semiconductors from the Ioffe Institute, St. Petersburg, Russia, in 1998 and 2010 correspondingly. His main research interests include laser physics, nanophotonics and nonlinear optics. He authored over 300 research publications, 1 book and 40 patents on these topics. He holds the position of Chief Researcher and heads Laboratory of Integrated Optics on Heterostructures at the Ioffe Institute. Concurrently, he chairs two Departments at LETI: Dpt of Physics and Modern Technologies of the Solid-State Electronics and Dpt of Optoelectronics. In 2013, he became an Honorary Professor at the University of Dundee, UK. In 2015, he was elected a Professor of the Russian Academy of Sciences. In 2025, he was elected Editor-in-Chief for Technical Physics Letters.
15:30 - 16:00	**Coffee break**	

16:00 - 17:00	**Lecture**	**Advances in Quantitative Analysis of Blood Flow with Dynamic Light Scattering Imaging**
	Igor Meglinski	Aston University, United Kingdom
		Igor Meglinski is a Professor of Quantum Biophotonics and Biomedical Engineering at Aston University (UK). He is a Faculty member at the Department of Mechanical, Biomedical & Design Engineering and affiliated with the Aston Institute of Photonic Technologies (AIPT). He has authored over 450 publications in peer-reviewed scientific journals and conference proceedings, in addition to more than 20 book chapters, 7 books, and several patents. He has delivered over 800 presentations at major international conferences, including over 300 plenary and invited lectures, as well as over 100 invited talks at the international research centres. In 2024 Professor Meglinski was recognized among the Top 100 in Photonics and as one of the Top 100 influencers in Life Sciences. He is Chartered Physicist (CPhys) and Chartered Engineer (CEng), Senior Member of IEEE, Fellow of Institute of Physics, International Institute of Acoustics and Vibration (IIAV), Royal Microscopical Society (FRMS), SPIE and OPTICA.
20:00	**Networking**	

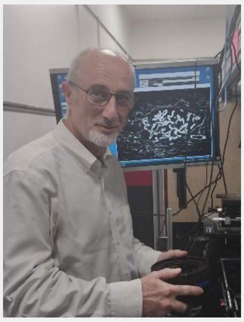
Tuesday 10/6/2025		
10:00 - 11:00	**Lecture**	**Looking and listening to light inside complex biological systems: extending the limits of microscopic imaging**
	Giannis Zacharakis	Institute of Electronic Structure and Laser – Foundation for Research and Technology, Greece
		Dr. Giannis Zacharakis is a Research Director at IESL – FORTH, and Head of the Laboratory for Biophotonics and Molecular Imaging. He is a Past President of the European Society for Molecular Imaging (ESMI), President between March 2019 –March 2020, Vice President between March 2018 – March 2019 and Member of the Council between 2014-2018. He received his BSc in Physics in 1997 and his PhD in 2002 from the University of Crete. During 2003 and 2004 he has been a Research Fellow in Radiology at Harvard University. His main fields of interest are biophotonics and biomedical imaging with focus on developing key enabling technologies for imaging biological processes in living systems. He is also a co-founder and the Chief Scientific Officer of Traqbeat Technologies PC (until 2023), a medical wearables start-up and the CEO/President of Kymatonics PC, a photonics innovation spin-off since 2024.
11:00 - 11:30	**Coffee break**	

11:30 - 13:00	**Keynote Lecture**	**Optoacoustic imaging - instrumentation, algorithms, and applications**
	Daniel Razansky	University of Zurich and Department of Information Technologies and Electrical Engineering, ETH, Switzerland
		Daniel Razansky is Full Professor of Biomedical Imaging with a double appointment at the Faculty of Medicine, University of Zurich and Department of Information Technologies and Electrical Engineering, ETH Zurich in Switzerland. He earned Biomedical and Electrical Engineering degrees from the Technion - Israel Institute of Technology and conducted postdoctoral research at the Harvard Medical School. Before moving to Zurich, Razansky was Professor of Molecular Imaging Engineering at the Technical University and Helmholtz Center Munich in Germany. His Lab pioneered several technologies for pre-clinical research and clinical diagnostics, among them the multi-spectral optoacoustic tomography and its multimodal combinations with therapeutic and diagnostic ultrasound, fluorescence microscopy, and magnetic resonance imaging. Prof. Razansky's research has been recognized by the German Innovation Prize, IPPA James Smith Prize, and multiple awards from the ERC, NIH, HFSP, SNSF, and DFG. He is a Fellow of the IEEE, SPIE, and Optica Societies.
13:00 - 14:30	**Lunch break**	
14:30 - 15:30	**Lecture**	**Illuminating Life: How Photonics and AI Can Shape the Future of Healthcare**
	Sergei Sokolovski	Aston Institute of Photonic Technologies, Aston University, United Kingdom
		Dr. Sergei G. Sokolovski is a Senior Research Fellow at Aston specializing in biophotonics, medical spectroscopy, and photonics-based diagnostic systems. His expertise spans the development of non-invasive optical technologies for cardiovascular disease detection, cancer treatment, and advanced imaging techniques. His research has significantly contributed to the fields of auto- fluorescence and imaging, photobiomodulation, and 3D laser bioprinting for tissue engineering. With a career spanning over multiple institutions, including the University of York, Glasgow, Dundee, and the National Academy of Sciences of Belarus, He has been involved in numerous international research collaborations. His work has led to an extensive portfolio of publications, book chapters, and patents. He has also played a key role in securing substantial research funding and mentoring postgrad students. His contributions continue to push the boundaries of biomedical photonics, advancing technologies that bridge fundamental research with real-world clinical applications.
15:30 - 16:00	**Coffee break**	

16:00 - 17:00	**Lecture**	**The use of Raman spectroscopy for DNA detection and tissue characterization**
	Veres Miklós	Aston University, United Kingdom HUN-REN Wigner Research Centre for Physics, Hungary
		Igor Meglinski is a Professor of Quantum Biophotonics and Biomedical Engineering at Aston University (UK). He is a Faculty member at the Department of Mechanical, Biomedical & Design Engineering and affiliated with the Aston Institute of Photonic Technologies (AIPT). He has authored over 450 publications in peer-reviewed scientific journals and conference proceedings, in addition to more than 20 book chapters, 7 books, and several patents. He has delivered over 800 presentations at major international conferences, including over 300 plenary and invited lectures, as well as over 100 invited talks at the international research centres. In 2024 Professor Meglinski was recognized among the Top 100 in Photonics and as one of the Top 100 influencers in Life Sciences. He is Chartered Physicist (CPhys) and Chartered Engineer (CEng), Senior Member of IEEE, Fellow of Institute of Physics, International Institute of Acoustics and Vibration (IIAV), Royal Microscopical Society (FRMS), SPIE and OPTICA.
17:00 - 18:30	**Poster Session**	

Wednesday 11/6/2025		
10:00 - 11:00	**Lecture**	**Photonics as a Tools for Biomedical Applications: Imaging, Diagnostics and Treatments**
	Edik Rafailov	Aston University, United Kingdom
		Prof Edik U. Rafailov received his Ph.D. degrees from the Ioffe Institute, St Petersburg. Since 1987, Prof. Rafailov has been engaged in the research and development of novel laser sources, nonlinear and integrated optics. He was responsible for the first demonstration of novel high-power Al-free laser diodes. For this work he individually (1993) and his research group (1994) were awarded funding from the International Science Foundation (ISF). He was a co-investigator on a project that received funding from the ISF (1994-1996) in collaboration with Professor Zh. I. Alferov (Nobel Prize winner in Physics in 2000). He moved to the University of St Andrews (UK) in 1997 and in 2005 Prof. Rafailov moved to University of Dundee, UK. In 2014 he and his Optoelectronics and Biomedical Photonics group moved to Aston University (UK). He has authored and co-authored over 550 articles in refereed journals and conference proceedings, including three books, ten invited chapters and numerous invited talks to SPIE, LEOS and CLEO. He also holds 10 UK and two US patents. Prof. Rafailov coordinated a €14.7M FP7 FAST-DOT project – development of new ultrafast lasers for Biophotonics

		applications and the €11.8M NEWLED project aims to develop a new generation of white LEDs. . Recently he coordinates the HE Pathfinder GlioLight and FET Mesa-Brain and NEUROPA projects. Ultimately, because of his vision over the past ten years, he has been awarded as a Coordinator and PI more than €65M with more than €13M granted to his group. His current research interests include high-power CW, ultrashort-pulse lasers; generation of UV/visible/IR/MIR and THz radiation, nano-structures; nonlinear and integrated optics; and Biomedical Photonics.
11:00 - 11:30	**Coffee break**	
11:30 - 12:30	**Lecture**	**Multispectral optical sensor for monitoring psychological stress**
	Victoria Barygina	University of Florence, Department of Physics and Astronomy, Italy
		Victoria Barygina obtained her Master's degree in Physiology with a focus on cell biology and histology in 2007 at Moscow State University named after M.V. Lomonosov (MSU). During her PhD studies at MSU, she collaborated with the M.M. Shemyakin–Yu.A. Ovchinnikov Institute of Bioorganic Chemistry (Russian Academy of Sciences) on studying the dynamic properties of fibrillarin with confocal microscopy techniques, FLIP, and FRAP, in combination with genetically mutated forms of the protein. In 2010, she relocated to Italy, where she embarked on a new PhD program at the Department of Experimental and Clinical Biomedical Sciences "Mario Serio" at the University of Florence. Her research focused on the redox biology of psoriasis and vitiligo and was conducted on primary skin cells and complex multi-cellular models. In 2020, Victoria earned a Master's degree in Psychobiology of Alimentary Disorders from the University Tor Vergata and Biomedical Campus in Rome, Italy and worked as a psychobiologist at the Institute of Neurosciences in Florence, where she developed nutrition schemes for patients with psychiatric disorders. Since 2022, Victoria has been a part of Francesco Saverio Pavone's group at the Department of Physics and Astronomy in Florence, as a project manager and project developer in the field of Health. She also contributes her expertise as a psychobiologist to the development of innovative non-invasive biosensors for real-time psychological state estimation using the multimodal fiber-probe spectroscopy device developed in the laboratory of Prof. Pavone.
12:30 - 13:00	**Discussions on Photonics Meeting Biology**	
13:30 - 20:00	**Networking**	

Thursday 12/6/2025		
10:00 - 11:00	**Lecture**	**Selected biomedical applications in Light sheet fluorescence microscopy**
	Pablo Loza-Alvarez	The Institute of Photonic Sciences, Spain
		Pablo Loza-Alvarez received his PhD in Laser Physics from the University of St Andrews, Scotland in 2000. He is currently the head of the "Super Resolution Light Microscopy and Nanoscopy" lab at ICFO. He has a strong experience in microscopy and, by introducing novel photonics tools, he has conducted research and development at the cutting-edge of several advanced imaging techniques.that have been applied in different biomedical fields. He has directed 8 PhD students, co-authored over 130 international journal publications, has written 7 patents. Dr Loza-Alvarez, has experience in leading European and national projects (public or private funding). Dr. Loza-Alvarez' group participates in two Euro-BioImaging Nodes: Super Resolution Node Barcelona and Barcelona Mesoscopic Imaging Node.
11:00 - 11:30	**Coffee break**	
11:30 - 13:00	**Keynote Lecture**	**Optoacoustic imaging - instrumentation, algorithms, and applications**
	Paul French	Imperial College London & Francis Crick Institute, United Kingdom
		Paul French received his BSc in physics and PhD in laser optics from Imperial College London, where he joined the academic staff of the Physics Department in 1994, having previously worked at the University of New Mexico and at AT&T Bell Laboratories. Today his multidisciplinary research is also based in a satellite laboratory at the Francis Crick Institute, having evolved from ultrafast dye and solid-state laser physics to biomedical optics for applications in cell biology, drug discovery and clinical diagnosis. Current interests include the development and application of multidimensional fluorescence and quantitative phase imaging technology for assays of biomolecular interactions, super-resolved microscopy, automated high content analysis, endoscopy and tomography, with an emphasis on more accessible and sustainable instrumentation (www.openScopes.com), including open-source approaches to modular hardware, data acquisition and analysis.
13:00 - 14:30	**Lunch break**	

14:30 - 15:30	**Lecture**	**Systems biology aided by optical spectroscopic techniques - New avenues to extend our understanding and capture of cancer**
	Mihaela Žigman	Max Planck Institute of Quantum Optics, Germany
		Mihaela Žigman studied Molecular Biology at the University of Ljubljana and earned her PhD from the University of Vienna. During postdoctoral research at the Institute of Molecular Biotechnology of the Austrian Academy of Sciences in Vienna, and at the Fred Hutchinson Cancer Research Center in Seattle, she investigated molecular mechanisms controlling cell division. Following her research at the University of Heidelberg, she joined the Ludwig Maximilians University in Munich in 2015. Mihaela established the Broadband Infrared Diagnostics (BIRD) research, dedicating the past decade to pioneering the development and establishment of infrared molecular spectroscopy as a powerful analytical tool for assessing and mapping human health. Through comprehensive clinical and molecular studies alongside technological developments, her research aims to leverage the power of infrared molecular profiling and data analytics to enhance medical disease diagnostics and longitudinal monitoring of health.
15:30 - 16:00	**Coffee break**	
16:00 - 17:00	**Lecture**	**Analyzing Vibrational Spectra with Machine Learning: Practical Methods, Tools, and Common Pitfalls**
	Tarek Eissa	Ludwig-Maximilians-University of Munich, Germany
		Tarek Eissa is a research scientist at Ludwig-Maximilians-University of Munich. His work combines machine learning, spectroscopy, and biomedicine, with a focus on analyzing infrared vibrational spectra of biofluids for biomedical applications. He holds a master's degree in Informatics from the Technical University of Munich, where he specialized in data engineering and analytics, and recently completed his doctorate at the same university.
17:00 - 18:30	**Poster Session**	

Friday 13/6/2025		
10:00 - 11:00	**Lecture**	**Novel ultrafast lasers for biomedical applications**
	Bojan Resan	University of Applied Sciences and Arts Northwestern Switzerland, Switzerland
		Bojan Resan received BS in physics from University of Zagreb, Croatia, MS from ENSPS in Strasbourg and Institute of Theoretical and Applied Optics, University of South Paris, France, and in 2004, PhD in optics from College of Optics/CREOL University of Central Florida, USA. He was in R&D management roles in Coherent Inc. Santa Clara, California, and from 2008 in Time-Bandwidth Products/JDSU/Lumentum in Zürich, Switzerland. Since 2017 he is at University of Applied Sciences and Arts Northwestern Switzerland and since 2019 a full professor of laser technology. Throughout his career he was investigating novel technologies for femtosecond lasers and their biomedical, industrial, and telecommunications applications. Currently, Prof. Resan is visiting professor in Attoworld group of Prof. Dr. Ferenc Krausz and Dr. Mihaela Zigman at Max-Planck Institute for Quantum Optics and Ludwig Maximilian University in Munich.
11:00 - 11:30	**Coffee break**	
11:30 - 12:30	**Lecture**	**A Roadmap from the Perspectives of the Metamaterials Effective Properties and Applications**
	Tatjana Gric	Vilnius Gediminas Technical University, Lithuania
		Professor Tatjana Gric, since 2009 has been engaged in the investigation of waveguide devices (waveguide modulators, filters etc.), namely on proposing their electrodynamical analysis of various complex structures (e.g., tissue-like structures). Another major goal of her studies is plasmonics as the examination of the interaction between electromagnetic field and free electrons in a metal. The optically-active nanostructures have been simulated and their fundamental photonic properties have been explored. During the past few years she has been working on the investigation of the nanostructured composites and their fascinating properties. She has authored and co-authored over 75 articles in refereed journals and conference proceedings. She also holds a 1LT patent. Currently she is a chair of COST Action CA23125.

12:30 - 13:30	**Lecture**	**Hybrid Local AI for Multimodal Analysis of Bioluminescence and ultra low intensity auto-luminescence Images**
	Vyacheslav Kalchenko	Weizmann Institute of Science, Israel
		Dr. Vyacheslav (Slava) Kalchenko, MD, PhD, is a Senior Research Fellow (the highest permanent academic rank) at the Weizmann Institute of Science in Israel. He earned his MD (1993), completed a neurology internship (1994), and received his PhD (1998) from Chita State Medical Academy (former USSR). Following a postdoctoral fellowship at the Weizmann Institute (2002–2004), he established and has since directed a core preclinical optical imaging facility currently focused on translational research and AI-driven bioengineering. His work integrates biophotonics, neurotechnology, and AI to develop optical and computational imaging tools for studying brain function, microcirculation, and physiological dynamics in preclinical models and clinical settings. Key innovations include multimodal fluorescence and laser speckle imaging techniques and anatomically realistic "bionic" phantoms. He actively fosters industry collaborations and contributes to several spin-off ventures. Dr. Kalchenko has authored over 100 peer-reviewed publications and delivered more than 50 international presentations, including invited lectures. He is a Senior Member of SPIE and a Fellow of the Royal Microscopical Society.
13:30 - 14:30	**Lunch break**	
14:30 - 15:00	**Closing and Best Poster Nomination**	
15.00-19.00	**Managers Meeting** (reserved for TETRA Action Main Committee Board)	

POSTER PRESENTATIONS

Two poster sessions with refreshments are scheduled for May 10 and May 12, from 17:30 to 19:00. During these sessions, a jury composed of school speakers will evaluate the presentations and select the winner of best presentation.

The abstracts are numbered according to the alphabetical order of the presenter's name.

SUBMITTED ABSTRACTS

1. Development of plasmon-waveguide resonance sensor for investigation of biological interactions

Alexandr Belosludtsev[1], Tomas Rakickas[1], Edita Voitechovic[1], Ignas Bitinaitis[1], Viktor Reshetnyak[2], Anatoly Suprun[2], Liudmyla Shmeleva[2]

[1]Center for Physical Sciences and Technology, Savanoriu ave. 231, LT-02300 Vilnius, Lithuania
[2]Taras Shevchenko National University of Kyiv, Volodymyrska Street 64/13, 01601 Kyiv, Ukraine

Surface plasmon resonance (SPR) technique for the monitoring of the biomolecule interactions have been established in the end of 20th century. The significant improvement of SPR method was made by the incorporation of the laser and camera into SPR setup. That let acquire, besides label free and real time analysis, the image of the analysed surface. Our work is devoted to the improvement of the null-ellipsometry based imaging SPR setup. In the work, we suggest to use plasmon-waveguide resonance sensor instead of a classical – gold-covered glass slide for the investigations of the organic molecule interactions. Our novel metal-dielectric multilayer coating let effectively rearrange the electric field distribution and significantly increase the sensor sensibility.

Acknowledgment: This project has received funding from the Research Council of Lithuania (LMTLT), agreement No S-LU-24-3.

2. Conical Refraction-Structured Beams as Potential Tools for Cancer Diagnostics

Diana Galiakhmetova[1], Nawal Mohamed[1], Fatima Khanom[1], Anton Sdobnov[2], Ivan Lopushenko[2], Alexander Bykov[2], Igor Meglinski[1], Edik Rafailov[1]

[1]Aston University, Birmingham, B4 7ET, UK
[2]University of Oulu, P.O. Box 4500, 90014 Oulu, Finland

Compared to traditional diagnostic methods based on intensity, the quantum property of light, such as orbital angular momentum (OAM), offers a technique of cancer recognition by phase structure rotation depending on the spatial field distribution in scattering media [1,2]. To study the propagation of vortex light carrying OAM through 5 μm-thick biopsies of healthy and cancerous tissues, we developed a Mach-Zehnder interferometer using a 4 mm-long Nd (3 at.%) doped KGd(WO4)2 biaxial crystal to generate conical refraction (CR) (Fig. 1a).

CR is a unique OAM generation method, producing three distinct beam structures: Raman, Poggendorff, and Lloyd rings (Fig. 1b). While the beam intensity degrades through tissue propagation, the phase preserves OAM shape and enables clear detection of cancer by its distinguished phase rotation, which is +13o for healthy and -44 o for cancer tissues. This method may be even further improved by shifting the laser wavelength from 633 nm to biological transparency windows [3,4]. Our study of light-tissue interaction for skin (0.5 mm), bone (0.5 mm), and brain (1 mm) confirms the possibility of deeper penetration using longer wavelengths within the (I) ~650–950 nm, (II) ~1100–1350 nm, or (III) ~1600–1870 nm ranges (Fig. 1c,d).

This paper is the first demonstration of CR-structured OAM beams for abnormal tissue diagnostics. We introduce a phenomenological framework linking OAM response to refractive index and scattering variations. Using biopsy tissues, we evaluated OAM stability in turbid media and established validated measurement protocols, advancing high-precision refractive index sensing for potential non-invasive cancer detection.

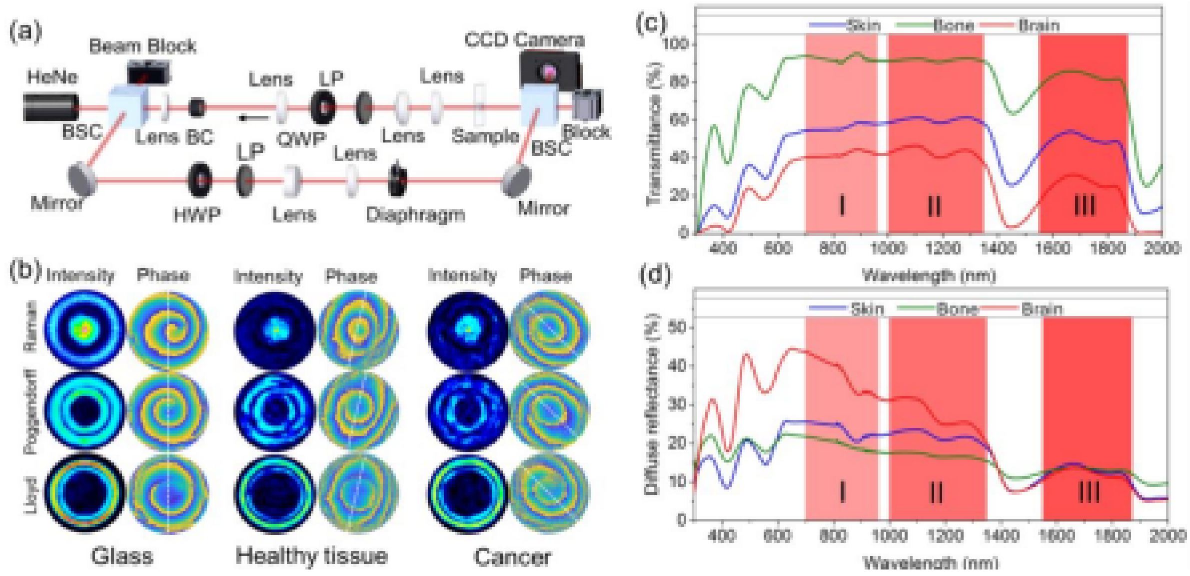


Fig. 1 (a) Diagram of the experimental setup for phase preservation of OAM: Mach–Zehnder interferometer: BC — biaxial crystal; BSC— beam splitter cube; LP — linear polariser; HWP and QWP — half- and quarter-waveplates, respectively. (b) Images of the intensity and phase distribution of a beam undergoing CR and propagating through the glass (reference), healthy and cancer tissues. (c) Total transmittance and (b) diffuse reflectance spectra of mouse head tissues measured with UV/Vis/NIR spectrophotometer.

Acknowledgements
The research is supported by COST Actions CA21159 (PhoBioS) and CA23125 (TETRA).

References

[1] I. Meglinski, et al., "Phase preservation of orbital angular momentum of light in multiple scattering environment," Light Sci. Appl. 13(1), 214 (2024).
[2] F. Khanom, et al. "Twists through turbidity: propagation of light carrying orbital angular momentum through a complex scattering medium," Sci. Rep. 14(1), 20662 (2024).
[3] Galiakhmetova D, et al., "Ultrashort pulsed laser in deep head tissues penetration for non-invasive optogenetics in near-IR windows". Optical Biopsy XXI, p. PC123730A.
[4] Galiakhmetova D, et al., "Ultra-short laser pulses propagation through mouse head tissues: experimental and computational study". IEEE Jour. Sel. Top. in Quan. Elect. 29(4: Biophotonics), pp.1-11.

3. Assessing the effects of prenatal cannabinoid consumption on fetal brain vasculature utilizing optical coherence angiography

Jessica Gutierrez[1], Manmohan Singh[1], Rajesh C. Miranda[2], Kirill V. Larin[1,2]

[1]Department of Biomedical Engineering, University of Houston, Houston, TX, USA
[2]Department of Neuroscience & Experimental Therapeutics, Texas A&M University, TX, USA

Prenatal cannabinoid exposure inhibits angiogenesis, leading to neurodevelopmental and morphological alterations in the developing fetus. These include fetal growth restriction, learning disabilities, and memory impairment, among other negative outcomes. There is a fundamental lack of understanding of the severe effects of cannabinoid consumption during pregnancy, especially on embryonic vascular development. Therefore, in this study, we assess the persistent effects of cannabinoid exposure on fetal brain vasculature in utero in a murine model. We analyzed the effects of different cannabinoid concentrations (0.0625mg/kg, 0.25mg/kg, and 1.0mg/kg) on fetal brain vasculature.

To assess the multiple dosing effects, we administered the same cannabinoid concentration at multiple gestational days (GD) 12.5, 13.5, and 14.5 and imaged at GD14.5. To assess the acute effects, we administered a single dose of CP55,940 at GD14.5 and imaged immediately after. We utilized correlation mapping optical coherence angiography to image changes in fetal brain vasculature caused by exposure to cannabinoids at each dosage. Results show significant vasoconstriction of the imaged blood vessel for all three administered dosages. When the fetal brain was exposed to the lowest dose, 0.0625 mg/kg of CP55,940, there was a greater decrease in the main blood vessel diameter over the 45-minute imaging time.

When the fetus was exposed to 1 mg/kg of CP55,940 for multiple days, the difference in vessel diameter, after 45-minutes, showed a smaller difference in percentage change, compared to the percent change over time for a single dose exposure. All these changes in fetal brain vasculature could lead to serious developmental defects.

4. Design of textile antenna and metatextile for medical applications

Amine Haj Taieb[1]
[1]ISAMS, University of Sfax

There are more and more promising applications of the textile metamaterials in medical field such as in : Healthcare and Hygiene products, Extracorporeal devices, implantable materials, Non-implantable materials. In this context textile give new opportunities for monitoring day to day activities using wearable technologies.

In this work we will focuse on the following case studies :
-Metamaterial textile implant interconnexion for health monitoring systems, such as stimulators, sensors, and drug delivery devices
-Wearable antennas for cancer detection
-Metamaterial for FSS Frequence selective Surface

The presented textile antennas and Metatextile can be new opportunities in medical application such as detecting any abnormalities in its tissues.

Reflection and Transmission coefficients can be collected and compared for modeling. Finally textiles are more and more developing into interdisciplinary high-tech products it interesting changes in the market.

5. A proposal for a distributed Local Service Provider Ecosystem for interfacing with a European Digital Infrastructure Consortium for neuroscience research

Roberto Inchingolo[1], Irene Costantini[1], Victoria Barygina[1], Francesco Pavone[1]

[1]LENS - European Laboratory for Non-Linear Spectroscopy, Sesto Fiorentino, Italy.

EBRAINS is a European open research infrastructure that gathers data, tools and computing facilities for brain-related research, and one of the key outcomes of the Human Brain Project, a European Future and Emerging Technologies (FET) Flagship project that ran from 2013 to 2023.

As EBRAINS is expected to transition into its future role as both a European Digital Infrastructure Consortium (EDIC) and a long-term Research Infrastructure (RI), a clear organisational framework is needed to ensure sustainable service delivery and stakeholder engagement. This works proposes a position on structuring a Ecosystem of Local Service Provider (LSPE) to align with EBRAINS' hybrid nature and outlines practical mechanisms to integrate and sustain local service providers (LSPs) in this evolving landscape.

LSPs, typically research institutions or scientific facilities embedded in EBRAINS National Nodes or operating independently, play a key role in complementing EBRAINS' centrally funded core services. These accessory services may include workflow customization, data production and annotation, training and education, on-site technical support, innovation management, and technology transfer.

Given that EBRAINS EDIC services must remain free of charge for final users and will have limited capacity to fund external contributions, the LSPE model proposes a cost-recovery mechanism to allow LSPs to sustain their activities. This includes the possibility of reimbursement for personnel, overhead, and consumables linked to EBRAINS-related tasks. Additionally, services provided by LSPs to private or industrial stakeholders should be fee-based, as commercial services fall outside the scope of free EDIC offerings.

Beyond direct service provision, participation in the LSPE also offers strategic advantages for LSPs. By being part of an organised, recognized ecosystem, they are better positioned to co-develop proposals for EU research and innovation funding calls. Featuring EBRAINS EDIC as a strategic partner enhances competitiveness and fosters broader scientific collaboration. This framework builds upon the legacy of the Human Brain Project's "Facility Hubs" and "Competence Centers," while establishing a more structured and financially viable model for long-term collaboration.

6. Label Free Imaging of Mouse Embryo Hemodynamics

Andrew L. Lopez III[1], Mohammad Dehshiri[1], Salavat Aglyamov[2], Kirill V. Larin[1,2]

[1]Dept of Biomedical Engineering, University of Houston, Houston, TX 77204 USA
[2]Dept of Mechanical and Aerospace Engineering, University of Houston, Houston, TX 77204 USA

Congenital cardiovascular defects (CCD) are malformations that occur in the developing heart. They impact 1% of all live births and are difficult to treat. Intracardiac procedures that intervene early have improved patient outcomes, but a deeper understanding of heart formation is necessary to better address this issue.

Here, we utilize the mouse embryo as a model system to determine the role of hemodynamics in heart development. Like humans, the embryonic mouse heart starts as a linear tube and within 24 hours performs cardiac looping, whereby the heart folds on itself and establishes the proper orientation for the development of future valves and chambers. Previous work suggests that shear stress due to blood flow regulates the proper formation of the early heart, but this remains vague. Towards this challenge, we have developed label-free imaging of the developing mouse heart using ultra-fast optical coherence tomography. Mouse embryos are live dissected and imaged at 19 volumes/sec. At this temporal resolution, several contraction cycles are captured in real time.

I have developed cross correlation algorithms to segment individual blood cells in the heart lumen and surrounding vasculature. Using this approach, we can visualize how hemodynamics differentiates as blood cells travel through the heart. With this information, we aim to develop an speed map of blood cell velocities. The impact of this work is to provide a direct measurement of shear stress in the developing heart and determine whether high shear stress coincides with areas of heart that fold as it proceeds through cardiac looping.

7. Dual-Channel Imaging of Cortical Dynamics in Freely Behaving Mice Using a Miniaturized Microscope

Alessia Mazzucato[1,2], Alessandro Scaglione[1,2]Jessica Lucchesi[1,2], Anna Letizia Allegra Mascaro[1,3], Francesco Saverio Pavone[1,2]

[1]LENS - European Laboratory for Non-Linear Spectroscopy, Sesto Fiorentino, Italy.
[2]University of Florence, Florence, Italy.
[3]IN-CNR Neuroscience Institute - National Research Council, Pisa, Italy.

We present the MiCe-μScope, a lightweight head-mounted microscope capable of dual-channel widefield imaging in freely moving mice. The system enables simultaneous acquisition of fluorescence and reflectance signals across the mouse cortex, facilitating the investigation of cortical activity during naturalistic behavior. To relate neural activity to behavior, we developed a preprocessing pipeline including temporal synchronization between imaging and behavioral data, segmentation of social interaction events, and time-aligned analysis of cortical dynamics.

A key feature of the system is its stroboscopic illumination: the microscope alternates blue (470 nm) and green (530 nm) LEDs for fluorescence and reflectance imaging, synchronized with camera acquisition. Leveraging this dual-channel design, we implemented emodynamic correction strategies using reflectance-based normalization and spectral unmixing to mitigate vascular artifacts and improve the fidelity of ΔF/F signals.

We applied this approach in a modified three-chamber social interaction paradigm. Behavioral segmentation revealed that mice spent more time exploring the central gap zone during their initial interactions. Simultaneously, mice exhibited increased activation in anterior cortical regions, independent of hemodynamic contributions, suggesting the emergence of a shared frontal network during social engagement.

This dual-channel platform enables reliable, widefield imaging of cortical dynamics in unrestrained animals. The integration of synchronized behavior tracking, interaction segmentation, and hemodynamic correction provides a robust framework for investigating the neural basis of social behavior and inter-brain coordination. Future developments aim to extend this approach to a fully untethered version of the system, enabling dual-channel mesoscale imaging and the study of inter-brain synchrony during social interaction in more naturalistic conditions.

8. Orbital Angular Momentum Beams in Turbid Media for High-Precision Diagnostics

Nawal Mohamed[1], Fatima Khanom[1], Diana Galiakhmetova[1], Anton Sdobnov[2], Ivan Lopushenko[2], Alexander Bykov[2], Edik Rafailov[1], Igor Meglinski[1]

[1]College of Engineering and Physical Sciences, Aston University, Birmingham, B4 7ET, UK
[2]Optoelectronics and Measurement Techniques Unit, University of Oulu, Oulu, 90014, Finland

We investigate propagation and phase stability of Orbital Angular Momentum beams in turbid tissue-like scattering medium, demonstrating its robustness for high-precision diagnosis of tissue samples, with potential for refractive index sensing in complex biological environments.

Orbital Angular Momentum (OAM) of light has emerged as a powerful tool in photonics, offering unique capabilities for information encoding, optical communication, and biomedical imaging [1-4]. OAM is a quantum property of light, characterized by the phase structure rotation depending on the field spatial distribution. Unlike conventional Gaussian beams, OAM-carrying beams possess helical phase fronts, enabling advanced light-matter interactions in complex scattering environments.

Recent studies have demonstrated the resilience of OAM beams in turbid media, highlighting their potential for non- invasive diagnostics and high-precision imaging [5]. This capability is particularly relevant for biomedical applications, where light scattering in biological tissues presents a major challenge. Pioneering work has shown that OAM beams retain their phase structure even in highly scattering environments, paving the way for novel approaches to tissue diagnostics and biochemical sensing [6].

To further explore these capabilities, this research systematically investigates four classes of structured light, including Laguerre-Gaussian (LG), Conical Refraction (CR), Bessel-Gaussian, and Poincaré beams [7], to establish a comprehensive framework for their propagation in complex media. By quantifying how different OAM modes respond to refractive index variations at the microscopic scale (10), current study aims to define the fundamental sensitivity limits for optical diagnostics. The findings have direct implications for the development of next-generation biomedical imaging technologies and could play a crucial role in early disease detection, particularly for conditions such as cancer and diabetes.

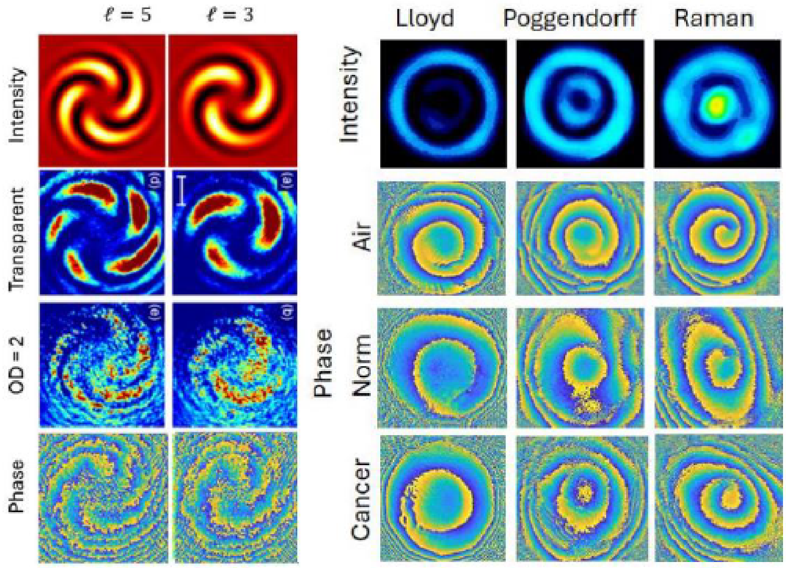


Figure 1 - . Left: the experimental results of propagation of LG beams (LG 5 and LG 3) through transparent and scattering medium OD=2-intensity (top) and phase (bottom), more details in Ref.5. Right: Intensity (top) and phase distributions of CR-based beams: Lloyd, Poggendorff and Raman after propagation through a transparent and turbid tissue-like scattering media mimicking normal and abnormal (cancerous) tissues.

References

[1] Y. Shen, X. Wang, Z. Xie, C. Min, X. Fu, Q. Liu, M. Gong, and X. Yuan, "Optical vortices 30 years on: OAM manipulation from topological charge to multiple singularities", Light Sci. Appl. 8, 90 (2019).
[2] A. Forbes, L. Mkhumbuza, and L. Feng, "Orbital angular momentum lasers", Nat. Rev. Phys. 6, 352–364 (2024).
[3] S. Franke-Amold, "30 years of orbital angular momentum of light", Nat. Rev. Phys. 4, 361 (2022).
[4] Y. Weng and Z. Pan, "Orbital Angular Momentum Based Sensing and Their Applications: A Review", J. Light. Technol. 41, 2007-2016 (2023)
[5] I. Meglinski, I. Lopushenko, A. Sdobnov, and A. Bykov, "Phase preservation of orbital angular momentum of light in multiple scattering environments", Light Sci. Appl. 13, 214 (2024)
[6] I. Meglinski, I. Lopushenko, A. Sdobnov, and A. Bykov, "Orbital Angular Momentum of Light in Scattering Medium", Optics & Photonics News, 35, 12 (2024)
[7] D. S. Simon, A Guided Tour of Light Beams (Second Edition): From Lasers to Optical Knots. IOP Publishing. (2020). ISBN: 9780750334655.

9. SOMA (Sistema di Orientamento e Associazione Multimodale) Project-Development of multisensory integrated system for the appreciation of visual art in hypo sighted individuals

Anna Maria Monciatti[1], Victoria Barygina[1], Francesco Pavone[1], Federico Carpi[1]

[1]LENS - European Laboratory for Non-Linear Spectroscopy, Sesto Fiorentino, Italy.

The project will develop a new “language of art” for the enjoyment of visual art pieces by hypo sighted individuals using sensory substitution techniques. The first phase will consist in the involvement of hypo sighted individuals to detect their unmet needs in the current museum paths for the hyposighted. After this process, it will try to build the language based on the detection of crossmodal influences in sighted individuals, to detect eventual association between color and sounds.

An haptic glove will be used to code for the information about the shapes and contours. The development will start from simpler colored shapes and auditory stimuli (simple sounds). The acoustic stimuli are modified in each of the important characteristics (pitch, spectral centroid, volume, frequency) one at a time, according to procedures developed with the Conservatory of Music. The coloured shapes will be modified too in their more important characteristics (saturation, luminance, value) one at a time too. The rules of association with color-sound will change based on different associations of the characteristics.

The stimuli will build from simple to more complex , firstly on blindfolded healthy subjects. When the association between the most important sound-color characteristics will be established via these exploratory experiments, and the haptic glove will be deemed appropriate for the coding of shapes and contours, a neuro/biofeedback aided training program will be developed for the hypo sighted individuals. This project will be developed in strict collaboration with cultural associations on a national and international level.

10. Gliomas and Meningiomas Grading and Characterization through Hyperspectral Imaging

Dorotea Nardini[1,2], Pietro Ricci[1,2], Anam Toaha[1,2] and Francesco Saverio Pavone[1,2]

[1]Dipartimento di Fisica e Astronomia, Università di Firenze, Sesto Fiorentino, Italy
[2]Laboratorio Europeo di Spettroscopia Non Lineare, Sesto Fiorentino, Italy

Accurate assessment of tumor grade is essential for eƯective treatment planning, while reliable tumor type discrimination – such as between gliomas and meningiomas, which together account for approximately 60% of primary brain tumors – is critical for diagnosis. Histopathology remains the gold standard for this purpose, however, it often requires several weeks to complete, causing significant delays in diagnosis and beginning of treatment. Currently, there is a lack of reliable analytical methods that can provide comparable accuracy within a shorter timeframe to potentially replace histopathology.

Here, we present HyperProbe, a hyperspectral imaging system that provides near real-time, label-free, quantitative data with high spatial resolution and a large field of view. This system combines wide-field microscopy and spectroscopy to acquire reflectance spectra for each pixel of the image. Because each molecule exhibits a specific spectral fingerprint, spectral unmixing allows us to quantify the concentration of individual molecules, enabling precise assessment of tissue composition.

Our study demonstrates that concentrations of lipids, diƯerences in oxy- and deoxy-hemoglobin, and oxidized and reduced cytochrome c oxidase serve as reliable biomarkers for meningioma grading and classification, showing strong concordance with histopathological analyses. Notably, by focusing on wavelengths sensitive to Hb and HbO2 concentrations, we also generate oxygen saturation maps. Additionally, autofluorescence imaging enables the detection of NADH and FAD presence in tissue, allowing us to calculate and map the optical redox ratio as a functional metabolic biomarker. Finally, 3D imaging of labeled gliomas was performed with a light-sheet microscope to correlate structural information with surface spectral data obtained from HyperProbe.

11. Evolase Oy

Maxim Odnoblyudov[1]

[1]Evolase Oy, Kivipolku 1, 56100, Ruokolahti, Finland

Evolase Oy is a Finnish company, which develops and commercialises ultrashort pulse fiber and diode-based lasers, laser control electronics and laser systems for scientific, bio- and medical, quantum and industrial applications. Constantly expanding product portfolio currently includes a range of CW and short pulse laser drivers, diode based ultrashort pulse laser modules, high power ultrashort pulse fiber lasers in IR/Green/UV spectral ranges and single frequency lasers. Evolase also offers design of customised laser systems according to customers' requirements.

Scientific qualification of Evolase science and engineering team includes development of various fiber based ultrashort pulse and ultranarrow linewidth lase sources with higher order harmonic generation used for real time Raman spectroscopy, FLIM spectroscopy, imaging microscopy for two and three photon generation.

Evolase is a part of the TETRA Cost action and Evolase representative will participate in the Summer School to establish contacts with experts in the biophotonics field and learn about requirements for lasers and optical sources needed to support state of the art research topics in biophotonics.

12. Influence of the light emission characteristics of fiber diffusers on heat generation and transport in vein tissue during Endovenous Laser Therapy

Daniel Pfaller[1], Mark Schrobback[2], Mo Zoheidi[2], Daniel Finkelstein[3], Ronald Sroka[1,4], Adrian Rühm[1,4]

[1]Laser-Forschungslabor, LIFE-Center, LMU University Hospital, LMU Munich, 82152 Planegg, Germany
[2]Oberon GmbH Fiber Technologies, 15745 Wildau, Germany
[3]Technische Hochschule Wildau, Germany, 15745 Wildau
[4]Department of Urology, LMU University Hospital, LMU Munich, 81377 Munich, Germany

Treatment of varicose veins by Endovenous Laser Therapy (ELT) is an established procedure but would benefit from further development in new innovative light application systems and optimization of treatment parameters. For this purpose, various emission characteristics of fiber-based light diffusers are tested in simulations, for typical treatment wavelengths used in clinical practice (1470 and 1940 nm), with the aim of finding the emission profile which ensures optimal treatment based on the thermal effect induced in the vein wall. This study seeks to contribute to this development by additional knowledge about physical processes involved in the thermal reaction of tissue to the ELT treatment.

The research will include simulations on both light and heat distribution within the tissue for different emission profiles of the light diffusers, treatment parameters like the pullback-velocity or the position of the fiber with respect to the vein wall, and tissue parameters like the vein diameter. To obtain realistic results, the change in optical properties induced by the energy deposition will also be considered. These findings will be compared to ex-vivo tests on vein tissue using existing diffusers, with a focus on the light and temperature distribution in the vein wall and the surrounding tissue. This approach will allow for a detailed examination of the model parameters with regard to the achieved treatment effects.

Overall, this research aims to advance knowledge in ELT by simulations and experiments, in an attempt to understand heat generation and transport in the laser-irradiated vein wall during treatment while protecting perivenous structures.

13. AI-Assisted Spectroscopic Breath Analysis for Neonatal Health Monitoring

Susmita Roy[1], Kiran Sankar Maiti[2], Adrian Ruhm[3], Ronald Sroka[3,4]

[1]Technical University of Munich, School of Medicine and Health, TUM University Hospital Rechts der Isar, Ismaninger Str. 22, 81675 Munich, Germany
[2]TUM School of Natural Sciences, Department of Chemistry, Technical University of Munich, Lichtenbergstr. 4, Garching, 85747, Germany
[3]Laser-Forschungslabor, LIFE-Center, LMU University Hospital, LMU Munich, 82152 Planegg, Germany
[4]Department of Urology, LMU University Hospital, LMU Munich, 81377 Munich, Germany

Despite technological progress, early-stage diagnosis of diseases remains hindered by inefficiencies, economic constraints, and limited clinical accessibility. This underscores the need for noninvasive, cost-effective, and in the future AI-driven diagnostic solutions. The human exhalome is typically stable, but disease-related biochemical changes can alter the metabolic com- position—many of them small and volatile —detectable in exhaled breath. Detecting disease via volatile organic compounds (VOCs) could provide a low-cost solution, even in asymptomatic stages [1]. After demonstrating the use of infrared (IR) spectroscopy in identifying breath biomarkers in adults, a pilot study was conducted on neonatal breath samples, focusing on preterm infants [2,3]. Preterm infants are at higher risk for neurological conditions such as cerebral palsy, with the risk being inversely correlated to gestational age. Breath samples were collected passively, adapted to each infant's respiratory support. However, low signal intensity and overlapping spectral features make metabolite detection difficult, which highlights the importance of AI-based methods for interpreting complex spectral data [4]. Additionally, metamaterials can be integrated into the IR spectroscopic measurement process to improve the signal to noise ratio and thus enhance the diagnostics accuracy. Realizing the full potential of breath-based diagnostics requires close collaboration between technologists, data scientists, and clinicians. Such interdisciplinary efforts are key to overcoming current limitations and advancing noninvasive diagnostics into clinical practice.

References

[1] R Griffiths, P de Haseth. J. A. Fourier Transform Infrared Spectrometry. John Wiley & Sons, 2007
[2] K. S. Maiti, S. Roy, R. Lampe, and A. Apolonski. Breath indeed carries significant information about a disease: Potential biomarkers of cerebral palsy. Journal of Biophotonics, 13(11):e202000125, 2020.
[3] N. Feddahi, L. Hartmann, U. Felderhoff-Muser, S. Roy, R. Lampe,K. S. Maiti, "Infrared spectro-scopic analysis of incubator sample änd breath from neonate". ACS Omega 9(28): 30625, 2024.
[4]. S. Roy and K. S. Maiti. Baseline correction for the infrared spectra of exhaled breath. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 318:124473, 2024.
[5]. A. Z. Nowakowski and M. Kaczmarek, Artificial Intelligence in IR Thermal Imaging and Sensing for Medical Applications. Sensors, 25(3), 891, 2025.

14. A non-invasive diagnostic approach for early-stage cancer detection

Kiran Sankar Maiti[1], Susmita Roy[2], Adrian Ruhm[3,4], Ronald Sroka[3,4]

[1]TUM School of Natural Sciences, Department of Chemistry, Technical University of Munich, Lichtenbergstr. 4, Garching, 85747, Germany
[2]Technical University of Munich, School of Medicine and Health, Department of Clinical Medicine, Klinikum rechts der Isar, Ismaninger Str.22, 81675 Munich, Germany
[3]Laser-Forschungslabor, LIFE-Center, LMU University Hospital, LMU Munich, 82152 Planegg, Germany
[4]Department of Urology, LMU University Hospital, LMU Munich, 81377 Munich, Germany

Many life-threatening diseases progress silently within the human body, symptoms only appear when they have reached an advanced stage. Among these, cancer is particularly concerning, causing millions of deaths worldwide each year[1]. The high mortality rate associated with such diseases is primarily due to the lack of effective diagnostic techniques for early-stage detection. Furthermore, existing diagnostic methods are often expensive and require invasive sample collection, posing not only physical risks but also psychological stress to patients [2]. A shift towards non-invasive diagnostic techniques could mitigate these challenges. Recent advancements have highlighted the potential of metabolic analysis of biofluids for non-invasive disease detection[3]. Among various biofluids, exhaled breath and urine are especially attractive for diagnostic purposes, as they can be collected entirely non-invasively[4-6]. Infrared (IR) spectroscopy, in particular, has demonstrated its capability to differentiate prostate cancer patients from healthy individuals through metabolic analysis of exhaled breath[7,8]. However, the widespread adoption of this promising technique requires further advancements in IR radiation sources, the sensitivity of IR detectors, and the efficient interpretation of infrared data. Artificially engineered metamaterials offer a promising solution by significantly enhancing IR radiation intensity and improving detection sensitivity. By optimizing the performance of both IR sources and detectors through advanced material design, these challenges can be effectively addressed. Realizing the full potential of this approach requires a multidisciplinary effort, bringing together technologists, data scientists, and medical professionals. Such collaborative efforts are essential to bridge the existing technological gaps and advance non-invasive diagnostic methods toward clinical application.

References

[1] Sung, H.; et.al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J. Clin. 2021, 71, 209–249.
[2] Singer, S. Psychosocial Impact of Cancer. In Recent Results in Cancer Research; Springer International Publishing: New York City, NY, USA, 2017; pp. 1–11.
[3] K. S. Maiti, M. Lewton, E. Fill and A. Apolonskiy, "Human beings as islands of stability: Monitoring body states using breath profiles,Sci. Rep. 9:16167, 2019.
[4] N. Feddahi, L. Hartmann, U. Felderhoff-Muser, S. Roy, R. Lampe, and K. S. Maiti, "Infrared spectroscopic analysis of incubator sample and breath from neonate". ACS Omega 9(28): 2024
[5] A. Lang, C. Heckl, M. Vogeser, T. Stauch, C. Homann, G. Hennig, and R. Sroka. Rapid spectrophotometric quantification of urinary porphyrins and porphobilinogen as screening tool for attacks of acute porphyria. J. Biomed. Opt., 23(05):1, 2018.
[6] P. Chalissery, C. Homann, H. Stepp, M. Eisel, M. Aumiller, A. Ruhm, A. Buchner, and R. Sroka. Influence of vitamins and food on the fluorescence spectrum of human urine. Lasers in Surgery and Medicine, 56(5):485–495, 2024.
[7] K. S. Maiti, E. Fill, F. Strittmatter, Y. Volz, R. Sroka, and A. Apolonski, "Towards reliable diagnostics of prostate cancer via breath" Sci. Rep. 11:18381, 2021.
[8] K. S. Maiti, E. Fill, F. Strittmatter, Y. Volz, R. Sroka, and A. Apolonski, "Standard operating procedure to reveal prostate cancer specific volatile organic molecules by infrared spectroscopy". Spectrochim. Acta Mol. Biomol. Spectrosc., 304:123266, 2024

15.Semiconductor lasers: What's next?

Grigorii S. Sokolovskii[1]

[1]Ioffe Institute, St.Petersburg, Russia

This talk will be focused on operational principles of semiconductor lasers and their emerging applications. It will cover some semiconductor laser basics, including formation of laser modes, differences between edge and surface-emitting lasers (as well as narrow and broad-aperture lasers), manipulation and analysis of semiconductor laser beams and utilization of the beam-propagation parameter M2. Then it will proceed to some modern and sophisticated techniques, such as generation of non-diffracting (Bessel) beams with semiconductor lasers and some aspects of achieving maximum power density with semiconductor light sources. The talk will be concluded with “What's next?” section that will discuss new biomedical applications of semiconductor lasers and problems to solve.

The author thanks RSF for support (grant No 21-72-30020-П, https://rscf.ru/project/21-72-30020/)

16. Monte Carlo modeling of polarimetric images of white matter of brain tissue for neurosurgery (MCM-Brain)

Meishu Wang[1,2], Sooyong Chae[1], Théotim Lucas[1], Tatiana Novikova[1]

[1]Institut Polytechnique de Paris, École Polytechnique, CNRS, LPICM, 91120 Palaiseau, France
[2]MOE Key Laboratory of Optoelectronic Imaging Technology and System, Beijing Institute of Technology, Beijing 100081, China

During brain tumor surgery, the identification of precise location of tumor boundary is very important, as it can help neurosurgeons to remove tumor zone completely and reduce the probability of tumor recurrence without excessively damaging normal tissues. It will also preserve neurological functions to the greatest extent after surgery. However, detecting glioma and glioblastoma tumor borders *in vivo* remains one of main challenges of modern neurosurgery.

Our proof-of-concept experimental studies demonstrated that wide-field imaging Mueller polarimetry is sensitive to the anisotropy of refractive index of white matter of healthy brain related to the presence of densely packed brain fibers, which are destroyed by brain tumor. It suggests using birefringence of healthy brain white matter as an optical marker for delineation of tumor border. However, the loss of retardance can not only be observed in the tumor zone, but also in the zones of brain fiber crossing and inclination.

Therefore, for differentiating the polarimetric images of brain tissue with complex 3D fiber distribution from the images of brain tumor we used the Monte Carlo modeling of interaction of polarized light with the optical models. Statistical analysis of the trends of depolarization, retardance and azimuth of optical axis in each model will be shown and discussed.

17. Artificial phantom mimicking near-IR optical properties of colon tissue for OCT performance evaluation

Natalia Wirtz[1,3], Oscar Caravaca[1], Adrian Rühm[3,4], Ronald Sroka[3,4], Michalina Gora[1,2]

[1] ICube Laboratory, CNRS, Strasbourg University, 1, Place de l'Hôpital - 67091 Strasbourg Cedex, France.
[2]Wyss Center for Bio and NeuroEngineering, Geneva, Switzerland
[3]Laser-Forschungslabor, LIFE Center, University Hospital, LMU Munich, 82152 Planegg, Germany
[4]Department of Urology, University Hospital, LMU Munich, 81377 Munich, Germany

Optical coherence tomography (OCT) is a noninvasive diagnosis technique that offers high resolution, three-dimensional visualization of tissue microstructure in vivo. In combination with white light endoscopy, it can be applied for real time microscopic diagnosis of colorectal cancer. The development of such devices requires appropriate testing modelsfor verification of the system's imaging performance and its suitability for the clinical use. A variety of in vivo models have been used in pre-clinical cancer studies, including large animal models. However, the use of large animal models is limited by the huge cost of disease development and the variation between animals, which makes it difficult to test the reproducibility of a device. Tissue and organ mimicking artificial phantoms with well-controlled optical properties can potentially be applied to solve this problem and provide the opportunity to evaluate the performance of optical and spectroscopic instruments under controlled experimental conditions.

In this study, an optical phantom was developed to mimic the thickness and near-infrared optical properties of each anatomical layer of a human colon, as well as the surface topography of colorectal polyps and the visual appearance observed with white light endoscopy.

This phantom may serve as a convenient tool to evaluate and standardize OCT image quality and measurement accuracy. This standardization can lead to improved performance of measurements conducted with clinical and research OCT devices, thus enhancing the reliability of diagnostic decisions and facilitating the development of innovative diagnostic technologies.

References

Zulina N. et al, Biomed Opt Express. 2021 12(2):955-968