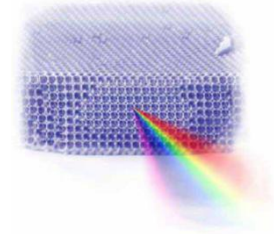
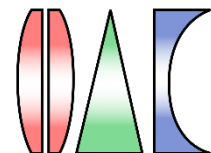


University of Belgrade
Institute of Physics Belgrade
Kopaonik, March 08-12, 2026



Book of Abstracts
19th Photonics Workshop
-International Conference-



19th Photonics Workshop 2026

Book of abstracts

Kopaonik, Serbia, March 08-12, 2026

Publisher, 2026:

Institute of Physics Belgrade

Pregrevica 118

11080 Belgrade, Serbia

Editors:

Marina Lekić, Zoran Grujić, Marta Bukumira

ISBN 978-86-82441-75-5

Printed by:

NEW IMAGE d.o.o.

Tošin Bunar 185, Belgrade

Number of copies: 60

CIP - Каталогизacija у публикацији
Народна библиотека Србије, Београд

535(048)

681.7(048)

66.017/.018(048)

PHOTONICS Workshop (19 ; 2026 ; Kopaonik)

Book of Abstracts / 19th Photonics Workshop, (International Conference),
Kopaonik, March 08-12, 2026 ; [organized by Institute of Physics Belgrade,
Photonics center [and] Optical Society of Serbia] ; [editors Marina Lekić, Zoran
Grujić, Marta Bukumira]. - Belgrade : Institute of Physics, 2026 (Belgrade : New
image). - 64 str. : ilustr. ; 25 cm

Tiraž 60. - Registar.

ISBN 978-86-82441-75-5

а) Оптика -- Апстракти б) Оптоелектроника -- Апстракти в) Технички
материјали -- Апстракти

COBISS.SR-ID 187669001

Scientific Committee:

Aleksander Kovačević, *Institute of Physics, University of Belgrade, Serbia*

Arne Wickenbrock, *Helmholtz Institute, Johannes Gutenberg University Mainz, Germany*

Borislav Vasic, *Institute of Physics, University of Belgrade, Serbia*

Branislav Jelenkovic, *Institute of Physics, University of Belgrade, Serbia*

Evgeny Gurevich, *University of Applied Sciences in Muenster, Germany*

Goran Mashanovich, *Optoelectronics Research Centre, University of Southampton, UK*

Gülnur Aygün, *Izmir Institute of Technology, Turkey*

Hrvoje Skenderovic, *Institute of Physics, Zagreb, Croatia*

Jovana Petrović, *Vinča Institute of Nuclear Sciences, University of Belgrade, Serbia*

Lars Klimaschewski, *Innsbruck Medical University, Austria*

Ljupčo Hadžievski, *Vinča Institute of Nuclear Sciences, University of Belgrade, Serbia*

Marina Lekić, *Institute of Physics, University of Belgrade, Serbia*

Pavle Andjus, *Faculty of Biology, University of Belgrade, Serbia*

Srdjan D. Antic, *Institute for Systems Genomics, Stem Cell Institute, University of Connecticut, USA*

Stanko Nikolić, *Institute of Physics, University of Belgrade, Serbia*

Stanko Tomić, *FInstP, Vinča Institute of Nuclear Sciences, University of Belgrade, Serbia*

Theo Scholtes, *Leibniz Institute of Photonic Technology, Germany*

Wolfgang Fritzsche, *Leibniz Institute of Photonic Technology, Germany*

Zoran Grujić, *Institute of Physics, University of Belgrade, Serbia*

Organizing Committee:

Branislav Jelenković (chair), *Institute of Physics Belgrade*

Marina Lekić (co-chair), *Institute of Physics Belgrade*

Zoran Grujić (webmaster), *Institute of Physics Belgrade*

Marta Bukumira (secretary), *Institute of Physics Belgrade*

Milica Vinić, *Institute of Physics Belgrade*

Aleksander Kovačević, *Institute of Physics Belgrade*

Bojana Bokić, *Institute of Physics Belgrade*

Filip Krajinić, *Institute of Physics*

Kolja Bugarski, *Vinča Institute of Nuclear Sciences*

Organized by:



Photonics center, Institute of Physics Belgrade



Optical Society of Serbia

Sponsors:



Ministry of Science, Technological Development and Innovation of the
Republic of Serbia








Telekom Srbija



Acknowledgements

Organizing Committee of the „19th Photonics Workshop 2026” expresses its gratitude for financial support obtained from:

-  Optical society of Serbia
-  Ministry of Science, Technological Development and Innovation of the Republic of Serbia
-  Analysis d.o.o
-  Telekom Srbija
-  BioQantSense project, finances by European Research Executive Agency under the GA No 101079355

Conference program

Sunday, March 08th

Chairman: Ivana Drvenica

16.00 – 16.30	Registration & opening
16.30 - 17.00	Riccardo Cicchi <i>Autofluorescence label-free high-contrast imaging of tumor margins in freshly excised gastro-intestinal biopsies</i>
17.00 - 17.20	Aleksandar Krmpot <i>Nonlinear Imaging and Laser Nano Surgery of Hyphae to Enable Electrophysiological Measurements</i>
17.20 – 17.40	Jovana Petrović <i>An AI-assisted multimodal diagnostic test for heart failure</i>
17.40 – 18.00	Danka Stojanović <i>Post-Exercise Cardiac Recovery as a Multiscale Dynamical Process</i>
18.00 – 18.15	Anton Tkach <i>Photon–plasmon interactions in active whispering gallery mode microresonators on plasmonic substrates</i>

Monday, March 09th**Chairman: Brana Jelenković**

16.00 - 16.30	Refreshment & workshop photo
16.30 - 17.00	Frank Setzpfandt <i>Quantum sensing with photon pairs</i>
17.00 - 17.30	Francesco Riboli <i>Optical limiter and isolators in nonlinear multilayer photonic systems</i>
17.30 – 17.50	Sara Nocentini <i>Reconfigurable optical and magnetic unclonable functions</i>
17.50 – 18.10	Marija Ćurčić <i>Integrating Classical Microscopy Concepts into Quantum Imaging with Undetected Light: Progress, Challenges and Perspectives</i>
18.10 – 18.25	Filip Krajinić <i>Quantum interferometry with undetected photons in mid-infrared spectrum</i>

Chairman: Jovana Petrović

20.00 - 20.30	Darko Zibar <i>Quantum Noise Limited Temperature-Change Estimation for Φ-OTDR Employing Coherent Detection</i>
20.30 - 21.50	Kirill Bogdanov <i>Composite diamond particles with various functionalization for biological applications</i>
21.50 - 22.10	Sergei Cherevko <i>Photothermal Conversion of Carbon Nanoparticles for Biomedical Applications</i>
22.10 – 21.30	Vladimir Djokovic <i>Plasmon-mediated enhancement of singlet oxygen production in Rhodamine B–gold nanoparticle systems stabilized by chitosan biopolymer</i>
21.30 – 21.50	Dušan Božanić <i>Low Power Density Actuation of Near-infrared Light-Driven AgBiS₂/mSiO₂ Nanomotors</i>

Tuesday, March 10th**Chairman: Biljana Ristić**

16.00 - 16.30	Refreshment
16.30 - 17.00	Giacomo Mazzamuto <i>Imaging neural tissue with Light-Sheet Fluorescence Microscopy A progress update</i>
17.00 - 17.30	Srdjan D. Antic <i>Backpropagating Action Potentials are Not Reliable Electrical Signals</i>
17.30 – 17.50	Nina Milosavljevic <i>A Naturalistic Light Monitoring Study Identifies Correlations Between Acute Light Exposure and Positive Mood</i>
17.50 – 18.10	Danijela Bataveljic <i>A role for astrocytes in Fragile X syndrome?</i>
18.10 – 18.30	Ana Jakovljević <i>Holographic and Nonlinear Microscopy for Investigating Glial Cell Morphology</i>

Chairman:

20.00 - 20.30	Szymon Pustelny <i>Searching for dark matter with optical sensors</i>
20.30 - 20.50	Arne Wickenbrock <i>Biomedical application of diamond-based quantum sensing</i>
20.50 - 21.10	Theo Scholtes <i>All-glass atomic vapour cells fabricated by laser-assisted bonding</i>
21.10 – 21.30	Zoran Grujić <i>Numerical analysis of frequency-modulated optical pumping with integrated hyperfine repumping for high-accuracy magnetometry</i>
21.30 – 21.50	Sinisa Djurovic <i>Fibre optic sensing – experiences and opportunities in the power and energy sector</i>
21.50 – 22.10	Ana Joža <i>FBG based optical load cell: Proof of Concept experience</i>

Wednesday, March 11th**Chairman: Aleksandar Krmpot**

16.00 - 16.30	Refreshment
16.30 - 17.00	Peter Galajda <i>Photonics and Microbiology</i>
17.00 - 17.20	Lóránd Kelemen <i>Biophysics with polymer microtools prepared and driven by light</i>
17.20 – 17.40	Biljana Ristić <i>Light-Driven Riboflavin loaded Au/TiO₂ micromotors as a Promising Strategy for Targeted Melanoma Therapy</i>
17.40 – 18.00	Tijana Miseljic <i>Coherent Anti-Stokes Raman Scattering (CARS) Microscopy as a Smart Tool for Nano/Micromotors Research</i>
18.00 – 18.20	Francesca Torrini <i>Butterfly-like microfluidic chip integrating a 3D-printed biomimetic scaffold for multimodal in vitro optical analysis of neuronal system</i>

Chairman: Zoran Grujić

20.00 - 20.30	Stanko Tomić <i>Quantum Computing of Many-body Effects in Quantum Dots</i>
20.30 - 20.50	Sanja Djurdjić Mijin <i>Sound-Driven Control of Quantum Light for Robust Time-Bin Photonic Qubits</i>
20.50 - 21.10	Nevena Božinović <i>Bioactive Structure Development on Ti/Zr/Ti/Si and Ti/Cu/Ti/Si Thin Films via Laser Irradiation</i>
21.10 - 21.25	Jovana Jelić <i>A Comparative Structural and Optical Study of Co, Cu, and Ni Complexes With Bioactive Hp2DAP Schiff Base</i>
21.25 – 21.40	Aleksandar Atić <i>Progress report on wide bandgap oxide semiconductor device modelling</i>
21.40 – 21.55	Dragan Lukić <i>New surveillance and detection system for military vehicles</i>

Thursday, March 12th**Chairman: Jasna Crnjanski**

16.00 - 16.30	Refreshment
16.30 - 17.00	Dejan Gvozdić <i>Nonlinear carrier-photon dynamics in semiconductor-based activation units for all-optical neural networks</i>
17.00 - 17.20	Nikola Vuković <i>Determination of transport characteristics of high-temperature THz quantum cascade lasers: numerical simulations and machine learning</i>
17.20 – 17.40	Milan Ignjatović <i>Dynamics of THz quantum cascade lasers under external optical feedback</i>
17.40 – 18.00	Danijela Danilović <i>A novel Ag-Bi-S-I chalco-halide nanomaterial for photovoltaic applications</i>
18.00 – 18.20	Mirjana Stojanović <i>Wavelength Demultiplexers Based on Self-Imaging in Optical Lattices with Length-Modulated Waveguides</i>
18.20 – 18.35	Kolja Bugarski <i>Scalability of splitters based on waveguide arrays</i>

Table of Contents

Quantum interferometry with undetected photons in mid-infrared spectrum	15
Filip Krajinić, Ivan Firez, Ana Kiković, Dupish Dupish, Marija Ćurčić, Marina Lekić, and Branislav Jelenković	
Quantum Computing of Many-body Effects in Quantum Dots	16
Stanko Tomić, FinstP	
Biophysics with polymer microtools prepared and driven by light	17
Lóránd Kelemen	
Imaging neural tissue with Light-Sheet Fluorescence Microscopy A progress update	18
Giacomo Mazzamuto, Laura Perego, Danila Di Meo, Franco Cheli, Michele Sorelli, Samuel Bradley, Federica Fenizi Caria, Josephine Ramazzotti, Irene Costantini, Antonietta Vilella, Martina Bodria, Jonathan Mapelli, Daniela Gandolfi, Michele Zoli, Francesco Pavone	
Integrating Classical Microscopy Concepts into Quantum Imaging with Undetected Light: Progress, Challenges and Perspectives	19
Marija M. Ćurčić, Marina Lekić, Tanja Pajić, Filip Krajinić, Dejan Pantelić, Dušan Arsenović and Brana Jelenković	
Bioactive Structure Development on Ti/Zr/Ti/Si and Ti/Cu/Ti/Si Thin Films via Laser Irradiation	20
Nevena Božinović, Suzana Petrović, Mirjana Novaković	
Plasmon-mediated enhancement of singlet oxygen production in Rhodamine B–gold nanoparticle systems stabilized by chitosan biopolymer	21
Vladimir Djoković, Jelena Pajović, Radovan Dojčilović, Dušan Božanić, Dušan Milivojević	
Fibre optic sensing – experiences and opportunities in the power and energy sector	22
Siniša Djurović	
A Naturalistic Light Monitoring Study Identifies Correlations Between Acute Light Exposure and Positive Mood	24
Chloe Roddis, Altug Didikoglu, Amy Gillespie, Catherine Harmer, Beatriz Bano Otalora and Nina Milosavljevic	
Backpropagating Action Potentials are Not Reliable Electrical Signals	25
Srdjan D. Antic	
A Comparative Structural and Optical Study of Co, Cu, and Ni Complexes With Bioactive Hp₂DAP Schiff Base	26
Jovana Jelić, Mirjana Radanović, Jelena Mitrić	
A role for astrocytes in Fragile X syndrome?	27

Danijela Bataveljic

Scalability of splitters based on waveguide arrays.....	28
Kolja Bugarski, Dimitris V. Bellas, Aleksandra Maluckov, Goran Z. Mašanović, Jovana Petrović	
Coherent Anti-Stokes Raman Scattering (CARS) Microscopy as a Smart Tool for Nano/Micromotors Research	29
Tijana Miseljic	
Composite diamond particles with various functionalization for biological applications.....	30
Kirill V. Bogdanov, Taisiia E. Didukh, Sergey A. Grudinkin , Alaxander V. Baranov	
Post-Exercise Cardiac Recovery as a Multiscale Dynamical Process	31
Danka B. Stojanović, Marjan Miletić, Marija D. Ivanović, Ljupčo Hadžievski, Jovana Petrović, Aleksandra Maluckov	
Evaluation and impact assessment of Horizon Europe project BioQantSense	32
Marina Lekić, Brana Jelenković	
FBG based optical load cell: Proof of Concept experience	33
Ana Joža, Jovan Bajić, Miroslav Dramićanin, Milan Kovačević	
Wavelength Demultiplexers Based on Self-Imaging in Optical Lattices with Length-Modulated Waveguides.....	34
Mirjana G. Stojanović, Kolja Bugarski, Aleksandra Maluckov, Jovana Petrović	
Quantum sensing with photon pairs.....	35
Frank Setzpfandt	
Autofluorescence label-free high-contrast imaging of tumor margins in freshly excised gastrointestinal biopsies	36
Dafne Suraci, Luca Tirloni, Joao L. Lagarto, Antonio Taddei, and Riccardo Cicchi	
Reconfigurable optical and magnetic unclonable functions.....	37
Sara Nocentini	
Nonlinear carrier-photon dynamics in semiconductor-based activation units for all-optical neural networks.....	38
Dejan Gvozdić, Jasna Crnjanski, Mladen Banović, Petar Atanasijević, Marko Krstić	
Optical limiter and isolators in nonlinear multilayer photonic systems.....	39
Francesco Riboli	
All-glass atomic vapour cells fabricated by laser-assisted bonding.....	40
D. Nodop, T. Kügler, F. Wittkämper, T. Scholtes, J. Rucker, and R. Stolz	
Quantum Noise Limited Temperature-Change Estimation for Φ-OTDR Employing Coherent Detection	41

Darko Zibar

Photon–plasmon interactions in active whispering gallery mode microresonators on plasmonic substrates	42
Tkach Anton Pavlovich, Molodcov Maksim Sergeevich, Strelkova Kseniia Vadimovna, Bogdanov Kirill Vadimovich	
Photothermal Conversion of Carbon Nanoparticles for Biomedical Applications	43
Sergei Cherevkov, Arina Efimova, Irina Arefina, Dmitrii Scherbinin, Vadim Rybin, Anna Vedernikova, Alexander Mitroshin, Elena Ushakova	
Low Power Density Actuation of Near-infrared Light-Driven AgBiS₂/mSiO₂ Nanomotors	44
Dušan K. Božanić, Danijela Danilović, Jelena Pajović, Biljana Ristić, Anamarija Abu el Rub, Vladimir Djoković, Anja Boisen, Tijana Mišeljić	
Progress report on wide bandgap oxide semiconductor device modelling	45
Aleksandar Atić, Novak Stanojević, Nikola Vuković, Milan Ignjatović, Nikola Basta, Aleksandar Milićević, Aleksandar Demić, Dragan Indjin, Jelena Radovanović	
Determination of transport characteristics of high-temperature THz quantum cascade lasers: numerical simulations and machine learning	46
Nikola Vuković, Aleksandar Milićević, Mihailo Stojković, Aleksandar Demić, Dušan Topalović, Novak Stanojević, Milan Ignjatović, Aleksandar Atić, Dragan Indjin, Jelena Radovanović	
A novel Ag-Bi-S-I chalco-halide nanomaterial for photovoltaic applications	47
Danijela Danilović, Radovan Dojčilović, Dušan K. Božanić, and Aleksandar R. Milosavljević	
Dynamics of THz quantum cascade lasers under external optical feedback	48
Milan Ignjatović, Novak Stanojević, Nikola Vuković, Aleksandar Milićević, Aleksandar Atić, Nikola Basta, Jelena Radovanović	
Butterfly-like microfluidic chip integrating a 3D-printed biomimetic scaffold for multimodal in vitro optical analysis of neuronal system	49
F. Torrini, C. Dallari and I. Masi, Maria Giovanna Cataldi, Anna Letizia Allegra Mascaro, Ana Jakovljevic, M. Rojas Rodríguez, Tanja Pajic, M. Catarzi, Francesco Saverio Pavone, M. Calamai, S. Nocentini, Brana Jelenkovic, Pavle Andjus, C. Credi	
An AI-assisted multimodal diagnostic test for heart failure	50
Jovana Petrović	
Sound-Driven Control of Quantum Light for Robust Time-Bin Photonic Qubits	51
Sanja Djurdjić Mijin, Snežana Lazić Knežević	
Light-Driven Riboflavin loaded Au/TiO₂ micromotors as a Promising Strategy for Targeted Melanoma Therapy	52
Biljana Ristić, Danijela Danilović, Radoš Stefanović, Jelena Pajović, Tamara Đukić, Vladimir Djoković, Vesna Ilić, Radovan Dojčilović	

Erythrocyte Light Side Scattering as a Label-Free Flow Cytometric Marker of Type 2 Diabetes Mellitus	53
Mihajlo D. Radmilović, Vesna Lj. Ilić, Dušan D. Vučetić, Radoš Stefanović, Biljana Ristić, Ana Petakov, Katarina Lalić, Aleksandar J. Krmpot, Ivana T. Drvenica	
Photonics and Microbiology.....	54
Peter Galajda	
Nonlinear Imaging and Laser Nano Surgery of Hyphae to Enable Electrophysiological Measurements	55
Tanja Pajić, Katarina Stevanović, Marta Bukumira, Nataša Todorović, Svetlana Savić Šević, Miroslav Živić, Mihailo Rabasović and Aleksandar Krmpot	
Searching for dark matter with optical sensors	56
S. Pustelny	
Numerical analysis of frequency-modulated optical pumping with integrated hyperfine repumping for high-accuracy magnetometry.....	57
Zoran D. Grujić, Theo Scholtes, Marija Ćurčić	
New surveillance and detection system for military vehicles	58
Dragan Lukić, Časlav Lukić	
Holographic and Nonlinear Microscopy for Investigating Glial Cell Morphology	59
Ana Jakovljević, Tanja Pajić, Filip Krajinić, Svetlana Savić-Šević, Branka Murić, Francesca Torrini, Caterina Dallari, Caterina Credi, Pavle Andjus, Branislav Jelenković	
Biomedical application of diamond-based quantum sensing	60
Arne Wickenbrock	
BioQantSense: Management Approaches and Lessons Learned from a WIDERA Twinning Project at the Institute of Physics Belgrade.....	60
Giulia Adembri, Donata Fornaciari, Pasqualina Pipino, Caterina Credi, Frank Setzpfandt, Christian Helgert, Marina Lekić, Dušica Vukcevic Stojiljkovic, Brana Jelenković	

Abstracts

Quantum interferometry with undetected photons in mid-infrared spectrum

Filip Krajinić^{1,2}, Ivan Firez¹, Ana Kiković¹, Dupish Dupish³, Marija Ćurčić², Marina Lekić², and Branislav Jelenković²

(1) *University of Belgrade, School of Electrical Engineering, Bulevar kralja Aleksandra 73, 11120, Belgrade, Serbia*

(2) *University of Belgrade, Institute of Physics Belgrade, Pregrevica 118, 11080, Belgrade, Serbia*

(3) *Institute of Applied Physics, Albert Einstein Str. 6, 07745, Jena, Germany*

Contact: F. Krajinić (filip@ipb.ac.rs)

Abstract. In recent years, considerable efforts have been devoted towards bringing quantum imaging and quantum sensing closer to real-life applications, particularly where classical states of light have reached fundamental limits. One such approach employs nonlinear interferometers to generate entangled photon pairs with highly non-degenerate wavelengths. In this method, the sample is probed at one wavelength, while the information about the sample is obtained by detecting its entangled partner. The detected photons never directly interacted with the object, which is why this approach is commonly referred to as quantum imaging/sensing with undetected photons [1]. The separation of the probing and detecting wavelength is enabled by the phenomenon of induced coherence without induced emission [2]. The key benefit of the technique with undetected photons arises when the probing photon lies in the mid-infrared (MIR) spectral range - where reliable light sources and detectors are commercially scarce due to low performances, high cost, and technological complexity - while the detected photon is in the visible or near-infrared, where high-quality detectors are readily available. This work employs nonlinear process of spontaneous parametric down-conversion (SPDC) in the silver-gallium-sulfide (AgGaS₂ or AGS) to produce a tunable photon pair source. By rotating the AGS crystal, we can change the wavelength of the probing mid-infrared photon from 5.6 μm to 10.9 μm, while the other photon used for detection is in near-infrared from 747 nm to 703 nm. Owing to its high and broad transparency, AGS enables the generation of the MIR photons above 5 μm [3], which is not achievable with other commonly used nonlinear media (such as lithium-niobate or potassium-titanyl-phosphate). Using this photon source, we have built a Michelson-like nonlinear interferometer in order to explore its capability for imaging and spectroscopy in the MIR spectrum.

Acknowledgement. This work was supported by the Horizon WIDERA 2021-ACCESS-03-01 grant, #101079355 “BioQantSense”.

REFERENCES

- [1] G. B. Lemos, V. Borish, G. D. Cole, S. Ramelow, R. Lapkiewicz, and A. Zeilinger, “Quantum imaging with undetected photons,” *Nature*, vol. 512, no. 7515, pp. 409–412, Aug. 2014, doi: 10.1038/nature13586.
- [2] L. J. Wang, X. Y. Zou, and L. Mandel, “Induced coherence without induced emission,” *Phys. Rev. A*, vol. 44, no. 7, pp. 4614–4622, 1991, doi: 10.1103/PhysRevA.44.4614.
- [3] G. Boyd, H. Kasper, and J. McFee, “Linear and nonlinear optical properties of AgGaS₂, CuGaS₂, and CuInS₂, and theory of the wedge technique for the measurement of nonlinear coefficients,” *IEEE J. Quantum Electron.*, vol. 7, no. 12, pp. 563–573, 1971, doi: 10.1109/JQE.1971.1076588.

ORCID: F.K. 0009-0008-0284-9426, I.F. 0009-0003-4669-6349, A.K. 0009-0000-0717-6947, D.D. 0009-0002-2193-3697, M.C. 0000-0001-6920-3461, M.L. 0000-0003-4814-2051, B.J. 0000-0001-8276-1169

Quantum Computing of Many-body Effects in Quantum Dots

Stanko Tomić, FinstP¹

(1) *Vinca Institute for Nuclear Sciences, The University of Belgrade, PO Box 522 Belgrade, Serbia*

Contact: S. Tomić (stanko.tomic@vinca.rs)

Abstract. Quantum mechanics is witnessing its second revolution. It is of fundamental academic interest and of paramount benefit for new and nascent industries and technologies. The QM is the driving force behind the discovery practical applications, such as quantum camera, quantum time, quantum computing or quantum cryptography, to name a few. Consumer electronics nowadays, like mobile phones, the Internet, GPS, or QLED TV, would be impossible without the progress in QM. The field of QM was established by Max Planck in 1900. From then on, tremendous effort has been dedicated to the study of QM, which led to the ground-breaking invention of the laser, the creation of entangled quantum particles, semiconductor quantum dots (QD), the cooling of atoms, quantum manipulation of individual atoms, and quantum computing (QC). The discovery of those phenomena was awarded by several Nobel Prizes, most notably in 2022 to Aspect, Clauser & Zeilinger for the discovery of entanglement and in 2023 to Ekimov, Brus and Bawendi for the discovery of QD. With a new paradigm and extremely efficient approaches to solving problems that were, until recently, in the realm of science fiction only. Quantum computation is the most anticipated new technology on the horizon. QC aims to solve challenging computational tasks by utilising rules of quantum mechanics to manipulate the information. Here, we propose to simulate quantum systems consisting of many thousands of atoms in QD and its many body phenomena on a quantum computer based on the arrays of Rydberg atoms. The precision and robustness offered by the Ry-mediated entanglement protocols are the key factors for their penetration and wider applicability in experiments and in nascent quantum industries. However, to realise them, one needs to control a large assembly of quantum objects with exquisite precision. This is a tremendously difficult task, both from the point of intellectual comprehension and from the technological point of view. Indeed, such academic developments spur the race in quantum technology, ultimately aiming at quantum supremacy, when the quantum computers will outperform the speed and abilities of conventional supercomputers when manipulating data. Along the overview of the historical context, I will review the program of my Fulbright Scholarship which is devoted to quantum computing with Rydberg atoms. I will offer the contribution to the current understanding and challenges of many-body processes in QD and how they can be addresses by Ry-atoms quantum computers.

REFERENCES

- [1] S. Haroche, *Nobel Lecture: Controlling photons in a box and exploring the quantum to classical boundary*, Rev. Mod. Phys. **85**, 1083 (2013)
- [2] H. Bernien, *Probing many-body dynamics on a 51-atom quantum simulator*, Nature **551** (7682), 579-584 (2017)

ORCID: 0000-0003-3622-6960

Biophysics with polymer microtools prepared and driven by light

Lóránd Kelemen¹

(1) *HUN-REN Biological Research Centre Szeged, Temesvári krt. 62, 6726 Szeged, Hungary*

Contact: L. Kelemen (kelemen.lorand@brc.hu)

Abstract. Task-specific microstructures can efficiently and versatilely support biophysical research. They can probe or actuate the object of their study or offer a size-matched support or microenvironment. Two-photon polymerization (TPP), as a laser-based direct writing method, can prepare such structures in 3D with size up to a millimeter and with minimum features in the 100 nm region. Numerous methods evolved in the past to actuate the mobile versions of the microstructures, optical tweezers (OT) being one of the most precise and efficient. The talk will introduce the methods of TPP and OT, and flash exciting examples of their common applications in microfluidic environments. These include an all-optical protein sensor device built inside a microfluidic channel [1], a mobile structure that supports multiview imaging of single non-adherent cells [2], and deformable soft microrobots that can facilitate spatially and temporally precise cell-cell interactions [3].

REFERENCES

- [1] L. Kelemen, E. Lepera et al., *Lab Chip* **19** (2019), 1985-1990.
- [2] G. Vizsnyiczai, A. Búzás et al., *Biomed Optics Express* **11** (2020) 945-962
- [3] G.T. Iványi, B. Nemes et al., *Adv Mater* **36** (2024) 2401115

ORCID: L.K. 0000-0001-7772-2165

Imaging neural tissue with Light-Sheet Fluorescence Microscopy

A progress update

Giacomo Mazzamuto^{1,2,3}, Laura Perego², Danila Di Meo², Franco Cheli², Michele Sorelli²,
 Samuel Bradley², Federica Fenizi Caria², Josephine Ramazzotti², Irene Costantini^{2,4},
 Antonietta Vilella⁵, Martina Bodria⁵, Jonathan Mapelli⁵, Daniela Gandolfi⁵, Michele Zoli⁵,
 Francesco Pavone^{1,2,3}

(1) *National Research Council – National Institute of optics (CNR-INO), Sesto Fiorentino (FI), Italy*

(2) *European Laboratory for Non-Linear Spectroscopy (LENS), Sesto Fiorentino (FI), Italy*

(3) *Department of Physics and Astronomy, University of Florence, Italy*

(4) *Department of Biology, University of Florence, Italy*

(5) *Dipartimento di Scienze Biomediche, Metaboliche e Neuroscienze, Università degli Studi di Modena e Reggio Emilia (UNIMORE), Italy*

Contact: G. Mazzamuto (giacomo.mazzamuto@ino.cnr.it)

Abstract. We present the latest advancements in high-resolution neuronal imaging from the Biophotonics Lab at CNR-INO and LENS, with a specific focus on Light-Sheet Fluorescence Microscopy (LSFM). This imaging technique is a powerful tool for high-resolution volumetric imaging of biological samples, offering fast acquisition speeds and reduced photodamage. Quad-SPIM is our latest custom-built light-sheet microscope [1], a high-speed, multi-color LSFM system specifically designed for large-scale imaging of large cleared human brain tissue with subcellular resolution. The system enables simultaneous four-channel acquisition and achieves imaging speeds of 3 cm³/h thanks to a custom optical design and an optimized software for data handling. We show the capabilities and performance of the microscope by imaging postmortem, optically cleared human brain samples, revealing cytoarchitectonic and vascular features across centimeter-scale volumes. Using light-sheet fluorescence microscopy and a specific fiber staining method, we investigate the multiscale organization of myelinated fibers in human brain tissue from the brainstem, Broca's area, hippocampus, and primary visual cortex [2]. An advanced spatial orientation analysis tool is used, employing unsupervised 3D multiscale Frangi filters to obtain orientation distribution functions and local orientation dispersion maps. This enables precise characterization of the directionality of white matter bundles, linking mesoscopic structural properties to orientation details computed at the native micrometric resolution of the optical setup. Finally, we take advantage of light-sheet fluorescence microscopy to visualize c-Fos, a marker of neuronal activity, in the entire mouse brain of animals that were previously exposed to cigarette smoke (CigS) and e-cigarette vapors (eCigV). The aim of this project is to perform a global mapping, i.e. a systematic and quantitative evaluation, of the active neuronal populations and its changes during withdrawal from chronic cigarette smoke and e-cigarette vapors.

[1] Perego, Laura, et al. "Quad-SPIM: A High-Speed, Multi-Color Light-Sheet Microscope for 3D Imaging of Large Cleared Human Brain Tissues." *Laser & Photonics Reviews* (2025): e01725.

[2] Sorelli, Michele, et al. "Myelinated fiber labeling and orientation mapping of the human brain with light-sheet fluorescence microscopy." *NeuroImage* (2025): 121581.

ORCID: G.M. 0000-0003-3077-3904, L.P. 0000-0002-5173-7606, D.D.M 0000-0001-6545-0676, F.C. 0009-0004-7793-4730, M.S. 0000-0002-0546-3157, S.B. 0009-0005-5008-6580, F.F.C. 0009-0000-7262-2675, J.R. 0009-0007-0341-9607, I.C. 0000-0002-8464-7324, A.V. 0000-0003-3820-0115, M.B. 0000-0002-6123-6709, J.M. 0000-0002-0381-1576, D.G. 0000-0003-2315-2309, M.Z. 0000-0002-8034-2849, F.P. 0000-0002-0675-3981

Integrating Classical Microscopy Concepts into Quantum Imaging with Undetected Light: Progress, Challenges and Perspectives

Marija M. Ćurčić¹, Marina Lekić¹, Tanja Pajić², Filip Krajinić¹, Dejan Pantelić¹, Dušan Arsenović¹ and Brana Jelenković¹

(1) *Institute of Physics, University of Belgrade, Serbia*

(2) *Faculty of Biology, University of Belgrade, Serbia*

Contact: M. M. Ćurčić (marijac@ipb.ac.rs)

Abstract. Quantum imaging with undetected light (QIUL) [1-3] has emerged as a powerful paradigm enabling imaging at wavelengths that interact with the sample but are never directly detected. By using mature and efficient visible-wavelength detectors, QIUL enables probing samples in the near- and mid-infrared spectral ranges. In these ranges, direct detection is difficult because suitable detectors are often nonexistent, limited in performance, or prohibitively expensive. These capabilities make QIUL particularly attractive for probing sensitive or otherwise challenging to image specimens. Within our Horizon Europe Twinning project BioQuantSense, we are developing and investigating novel quantum imaging architectures with the particular focus on advancing QIUL towards applications in biological microscopy.

In this work, we present our ongoing efforts aimed at enhancing the capabilities of QIUL systems in terms of compactness, versatility and spatial resolution. Our research investigates how principles and methodologies from classical optical microscopy can be adapted and incorporated into QIUL-based imaging platforms. An important motivation of this work is to evaluate the extent to which quantum imaging schemes can benefit from established classical microscopy strategies. We also seek to identify practical strategies for moving QIUL beyond from proof-of-principle demonstrations towards more application-oriented and robust systems, suitable for biological samples. We will discuss the design choices, experimental approaches and current progress across several QIUL-based set-ups presently under development. Where possible, preliminary results will be shown to illustrate the potential of these systems.

Acknowledgement. This work was supported by the Horizon WIDERA 2021-ACCESS-03-01 grant, #101079355 “BioQantSense” and bilateral project “Classical and quantum biophotonics” (HU-SRB).

REFERENCES

- [1] G. B. Lemos, V. Borish , G. D. Cole, S. Ramelow, R. Lapkiewicz, and A. Zeilinger, *Nature* **512**, 409 (2014).
- [2] León-Torres, J. R., Dosan, V. L., Ćurčić, M. M., Lagarrigue, A., Setzpfandt, F., Gräfe, M., & Gili, V. F., *Laser & Photonics Reviews*, **e02356** (2025).
- [3] J. R. León-Torres, F. Krajinić, M. Kumar, M. Gilaberte Basset, F. Setzpfandt, V. Flavio Gili, B. Jelenković and M. Gräfe, *Optics Express* **32** (2024), 35449-35461.

ORCID: M.Ć. 0000-0001-6920-3461, M.L. 0000-0003-4814-2051, T.P. 0000-0003-3794-7655, F.K. 0009-0008-0284-9426, B.J. 0000-0001-8276-1169

Bioactive Structure Development on Ti/Zr/Ti/Si and Ti/Cu/Ti/Si Thin Films via Laser Irradiation

Nevena Božinović¹, Suzana Petrović¹, Mirjana Novaković¹

(1) *Institute of nuclear sciences VINCA, National Institute of the republic of Serbia.*

Contact: N. Božinović (nevena.bozinovic@vin.bg.ac.rs)

Abstract. The fundamental trend in the development of biocompatible materials such as thin films is to enhance their characteristics to guarantee the operation of these systems without posing any risks to human health [1-6]. Therefore, this study aimed to investigate the relationship between the chemical composition, morphology, microstructural and biocompatibility of materials based on titanium thin layers that were obtained through an unconventional process of physical deposition from the vapor phase using a multidisciplinary approach. On the other hand, irradiation with ultrashort laser pulses in the pico- and femtosecond time range was carried out to more thoroughly investigate the adherence of cell cultures on the materials thus generated, as well as the formation of micro- and nanostructures. The deposited and laser-modified thin layers were characterized using scanning electron microscopy (SEM), atomic force microscopy (AFM) and optical profilometry. The uniformity of the deposited layers in the cross-section was confirmed by scanning transmission electron microscopy (STEM), whereby the depth profiles were used for the determination of the elemental composition and spatial distribution of the elements. Chemical analysis of the surface of Ti/Cu/Ti and Ti/Zr/Ti thin layers revealed enhanced oxidation following by laser irradiation. Furthermore, STEM/EDS research revealed that elements of the subsurface layer diffused as a result of laser radiation, and zirconium and copper were consistently distributed across the layer's depth, with a concentration of around 1-2 percent by weight. The results of the MTT test and the analysis of morphological changes showed that the laser-modified thin layers are not cytotoxic. The mean viability of MRC-5 cells in contact with laser-modified Ti/Zr/Ti and Ti/Cu/Ti is higher than the mean viability of cells without thin layers as well as the control sample (pure titanium).

REFERENCES

- [1] J.B. Park, Y. Kon Kim, Metallic biomaterials, in: R. Narayan (Ed.), *Biomater. Princ. Appl.*, Second, Springer, Cham., University of Toronto, Toronto, ON, Canada, 2002: pp. 1–20.
- [2] Y. Lee, H.H. Tan, C. Jagadish, S.K. Karuturi, Controlled Cracking for Large-Area Thin Film Exfoliation: Working Principles, Status, and Prospects, *ACS Appl. Electron. Mater.* 3 (2021) 145–162.
- [3] H.J. Griesser, *Thin Film Coatings for Biomaterials and Biomedical Applications*, Woodhead Publishing, 2016.
- [4] S. Rubin, D. Mizrahi, N. Friedman, H. Edri, T. Golan, *The World of Advanced Thin Films: Design, Fabrication, and Applications*, 4 (2023).
- [5] S.M. Rossnagel, Thin film deposition with physical vapor deposition and related technologies, *J. Vac. Sci. Technol. A Vacuum, Surfaces, Film.* 21 (2003) S74–S87.
- [6] F. Madaraka Mwema, T.-C. Jen, L. Zhu, *Thin Film Coatings; Properties, Deposition, and Applications*, n.d. <https://www.routledge.com/>.

ORCID: N.B. 0000-0002-4762-4115, S.P. 0000-0002-8894-692X, M.N. 0000-0001-7103-0117

Plasmon-mediated enhancement of singlet oxygen production in Rhodamine B–gold nanoparticle systems stabilized by chitosan biopolymer

Vladimir Djoković¹, Jelena Pajović², Radovan Dojčilović¹, Dušan Božanić¹,
Dušan Milivojević¹

(1) Vinča Institute of Nuclear Sciences, National institute of the Republic of Serbia, University of Belgrade, P. O. Box 522, 11001 Belgrade, Serbia

(2) University of Belgrade, Faculty of Physics, 11001 Belgrade, Serbia

Contact: V. Djoković (djokovic@vinca.rs)

Abstract: Chitosan-stabilized gold nanoparticles with different morphologies were prepared through chemical reduction of gold precursors. Their influence on the optical response and photosensitizing performance of rhodamine B was examined by comparing dye solutions containing chitosan alone with those incorporating chitosan–gold nanoparticle assemblies. The presence of gold nanoparticles led to pronounced modifications of rhodamine B fluorescence as well as its ability to generate singlet oxygen. Both fluorescence emission and singlet oxygen production were enhanced, an effect attributed to plasmonic excitation of the metal nanostructures under irradiation. The photosensitizing behavior of rhodamine B was further evaluated by electron paramagnetic resonance (EPR) spectroscopy using TEMP as a spin-trapping probe. Singlet oxygen formation was quantified through variations in the EPR signal intensity of the TEMPO radical adduct. The results indicate that gold nanoparticles promote singlet oxygen generation, whereas chitosan affects the stability of TEMPO, leading to a gradual decrease in the EPR signal, particularly at extended irradiation times.

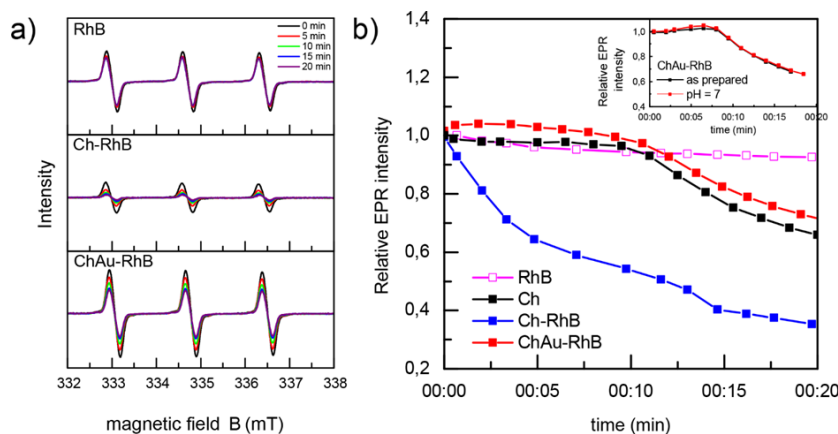


Figure 1 a) EPR TEMPO signals of RhB, Ch-RhB and ChAu-RhB recorded at various times (0, 5, 10, 15 and 20 min) after light excitation of the photosensitizer; b) Time dependence of the EPR signal intensities for RhB, Ch, Ch-RhB, and ChAu-RhB solution samples, normalized to their initial intensity (I_0) at $t = 0$ s. Inset: time dependence of the normalized EPR signal intensity of ChAu-RhB at pH 5 (initial pH) and pH 7.

REFERENCES

- [1] J. Pajović et al. *Colloid and Polymer Science* **304** (2026) 269–276.

ORCID: V. Dj. 0000-0001-8237-1101; J. P. 0000-0002-3644-0118; R. D. 0000-0002-3478-8268;
D. B. 0000-0001-8246-9635; D. M. 0000-0001-8924-2679

Fibre optic sensing – experiences and opportunities in the power and energy sector

Siniša Djurović¹

(1) Power & Energy Division, Department of Electrical and Electronic Engineering, School of Engineering, The University of Manchester, PO Box 88, Manchester, M13 9PL, UK

Contact: S. Djurović (Sinisa.durovic@manchester.ac.uk)

Abstract. The global push for decarbonization of our economy, including in particular the electrification of our transportation and the decarbonization of our energy network, is imposing ever increasing performance requirements for technology in the power and energy sector. There is thus an increased interest to optimize the utilization and consumption of the electrical device useful in-service life, be this device e.g. an automotive propulsion motor, a large grid power electronic inverter interface or a power transmission network. To achieve this a breakthrough is needed in the ability to measure in-situ a multitude of multi-physical measurands (e.g. temperature, strain, magnetic field, electric field etc...) in or around the complicated and often confined electromagnetic interference (EMI) rich geometries of these devices which has hitherto not been widely available. Fibre optic sensors have emerged as a possible solution to in situ multi-physical sensing in the power and energy sector, where the application of a particular class of reasonably mature but not yet fully explored in this context sensors, the fibre Bragg grating (FBG) sensors has been receiving increased interest in recent years. The FBGs offer inherent features of EMI immunity, small size, multiplexing capability and good response which are very attractive in the power and energy arena, where the standard sensing techniques are unable to compete. This talk will provide a review of a range of industrial and academic studies [1-6] on the application of FBG sensors in the power and energy sector and the key opportunities and challenges in the photonics and the application areas that could if addressed unlock considerable prospects for wider commercial application of this technology in the sector.

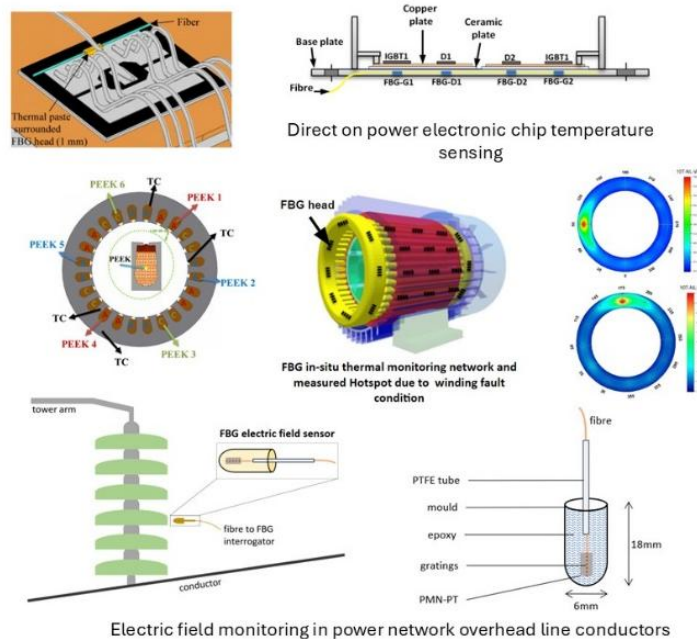


Figure 1. Examples of fiber optic sensign applications in the power and energy sector devices [1-6].

The aim of the talk is to present the current state of the art including the author's considerable work in this area to the photonics audience, illustrate the challenges where collaboration between the power and energy and the photonics experts would unlock credible opportunities and stimulate potential partnerships in this field.

REFERENCES

- [1] A. Mohammed *et al.*, "Distributed Thermal Monitoring of Wind Turbine Power Electronic Modules Using FBG Sensing Technology," in *IEEE Sensors Journal*, vol. 20, no. 17, pp. 9886-9894, 1 Sept.1, 2020
- [2] A. Mohammed, J. I. Melecio and S. Djurović, "Stator Winding Fault Thermal Signature Monitoring and Analysis by In Situ FBG Sensors," in *IEEE Transactions on Industrial Electronics*, vol. 66, no. 10, pp. 8082-8092, Oct. 2019
- [3] V. Ramnarine, V. Peesapati and S. Djurović, "Electrodeless Piezoelectric-Based Sensor for Electric Field Measurement in High-Voltage Applications," in *IEEE Transactions on Instrumentation and Measurement*, vol. 74, pp. 1-10, 2025
- [4] A. Mohammed, J. I. Melecio and S. Djurović, "Electrical Machine Permanent Magnets Health Monitoring and Diagnosis Using an Air-Gap Magnetic Sensor," in *IEEE Sensors Journal*, vol. 20, no. 10, pp. 5251-5259, 15 May15, 2020
- [5] H. Ren *et al.*, "In Situ Contact Pressure Monitoring of Press Pack Power Module Using FBG Sensors," In *IEEE Transactions on Instrumentation and Measurement*, vol. 71, pp. 1-11, 2022
- [6] S. Chen, D. Vilchis-Rodriguez, M. Barnes and S. Djurović, "Direct On-Chip IGBT Thermal Sensing Using Adhesive Bonded FBG Sensors," in *IEEE Sensors Journal*, vol. 23, no. 19, pp. 22507-22516, 1 Oct.1, 2023

A Naturalistic Light Monitoring Study Identifies Correlations Between Acute Light Exposure and Positive Mood

Chloe Roddis^{1*}, Altug Didikoglu^{1,2*}, Amy Gillespie^{3,4}, Catherine Harmer^{3,4}, Beatriz Bano Otalora¹ and Nina Milosavljevic¹

(1) *Centre for Biological Timing, Division of Neuroscience, School of Biological Sciences, Faculty of Biology Medicine and Health, University of Manchester, Manchester M13 9PL, United Kingdom*

(2) *Department of Neuroscience, Izmir Institute of Technology, Gulbahce, Izmir 35430, Turkey*

(3) *Department of Psychiatry, University of Oxford, Oxford, OX3 7JX, United Kingdom*

(4) *NIHR Oxford Health Biomedical Research Centre, Warneford Hospital, Oxford, OX3 7JX, United Kingdom*

Contact: N. Milosavljevic (nina.milosavljevic@manchester.ac.uk)

Abstract. Light influences not only vision but also mood, cognition, and physiology. As a non-invasive and accessible tool, it holds potential for enhancing sleep and well-being. However, understanding how naturalistic light exposure affects emotional states in real-world settings is essential for translating this into meaningful interventions. This study examined how both recent and cumulative light exposure relate to subjective mood in daily life.

Fifty-one healthy adults participated in a one-week observational field study. Participants wore light sensors (Condor Actlumus) to measure melanopic Equivalent Daylight Illuminance (melanopic-EDI) and Fitbits to track sleep and physiological activity. They completed daily surveys, including sleep diaries and mood ratings across seven variables: Happy, Relaxed, Energetic, Motivated, Carefree, Enjoyment, and Accompanied, using 0–100 visual analogue scales. Initial analyses revealed positive associations between light exposure and all mood variables, especially over short intervals. Linear mixed models showed that recent light exposure (particularly within the past 30 minutes) was positively associated with feeling energetic, motivated, and happy. Longer intervals (up to 4 hours) also showed effects, though weaker. Additionally, cumulative daily exposure above 1000 and 250 melanopic lux thresholds was associated with higher average ratings of happiness, relaxation, and enjoyment. Adjusting for covariates such as time awake and subjective sleepiness reduced but did not eliminate these acute effects, indicating that light has a distinct impact on mood. The findings suggest that acute light exposure may influence energy and motivation via different mechanisms than those underlying general positive affect. In conclusion, both short-term and sustained light exposure were associated with improved mood in real-world contexts. These results emphasise the importance of intensity and duration of light exposure and provide a foundation for future research into light-based interventions for mental health and well-being.

Backpropagating Action Potentials are Not Reliable Electrical Signals

Srdjan D. Antic^{1,2}

(1) UConn Health, School of Medicine, Farmington, Connecticut, 06030, USA

(2) Institute for the Brain and Cognitive Sciences Storrs, CT 06269, USA

Contact: S. Antic (antic@uchc.edu)

Abstract. Electrical signaling in neurons of the central nervous system underlies a wide range of brain functions. Among the diverse electrical signals employed by neurons, the most prominent is the fast sodium-dependent nerve impulse, or action potential (AP). APs propagate bidirectionally: forward along the axon to drive synaptic transmission, and backward into the dendritic tree to influence synaptic integration and plasticity. In cortical and hippocampal pyramidal neurons, these backpropagating action potentials (bAPs) play a central role in dendritic signaling and spike-timing-dependent plasticity (STDP). Most experimental and theoretical frameworks implicitly assume that bAPs are reliable signals that faithfully convey somatic spiking to dendritic synapses. Here, we review experimental evidence demonstrating that this assumption is frequently violated. Across large regions of the pyramidal neuron dendritic arbor, particularly distal apical branches and tuft dendrites, bAP amplitude displays pronounced spatial and temporal variability. This variability includes: (i) activity-dependent attenuation, (ii) frequency-dependent amplification, (iii) branch-specific propagation failures, and (iv) trial-to-trial stochastic AP flickering. We summarize five experimentally documented forms of bAP variability, and discuss how stochastic backpropagation may shape synaptic plasticity in computational neuroscience. In particular, we argue that variability in bAP propagation introduces probabilistic gates that constrain the coincidence of dendritic depolarization (bAPs) and synaptic input (EPSPs), thereby modulating STDP. Finally, we consider broader implications of dendritic AP flickering for cortical information processing, including redundancy reduction, signal averaging, evidence accumulation, and error-correcting strategies in cortical circuits.

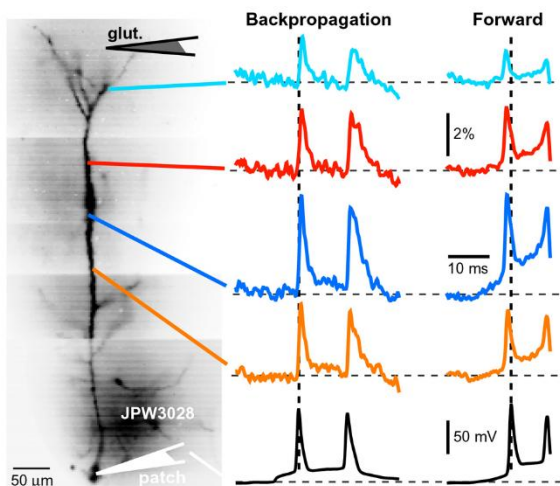


Figure 1. Bidirectional propagation of fast action potentials along the apical dendrite of a cortical pyramidal neuron. Brain slices were prepared from rat prefrontal cortex. A layer 5 pyramidal neuron was whole-cell patch-clamped and filled with the voltage-sensitive dye JPW3028 via the patch pipette (patch). **Backpropagation:** Somatic current injection elicited two action potentials that backpropagated into the apical dendritic tree. Voltage waveforms were recorded simultaneously at four dendritic locations. **Forward propagation:** Glutamatergic stimulation of apical tuft dendrites by microiontophoresis (glut.) evoked an action potential that initiated in the dendrite and propagated toward the soma.

ORCID: A.S. 0000-0001-7102-4710

A Comparative Structural and Optical Study of Co, Cu, and Ni Complexes With Bioactive Hp₂DAP Schiff Base

Jovana Jelić¹, Mirjana Radanović², Jelena Mitrić¹

(1) Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11 080 Belgrade, Serbia

(2) University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, 21 000, Novi Sad, Serbia

Contact: J. Jelić (jelic@ipb.ac.rs)

Abstract. Hydrazone-based Schiff bases represent a significant class of compounds with established biological relevance and strong metal-chelating ability, often leading to enhanced pharmacological activities upon complexation [1]. This study focuses on the synthesis and characterization of coordination compounds derived from the pentadentate N5 donor ligand, bis(3-chloropyridazine-6-hydrazone)-2,6-diacetylpyridine (Hp₂DAP), with Co(III), Cu(II), and Ni(II) ions. Three distinct complexes were isolated: a binuclear cobalt(III) complex, [Co₂(μ-Hp₂DAP-2H)₂(μ-O₂)]·4H₂O (CoHp₂DAP); a mononuclear copper(II) complex, [Cu(Hp₂DAP-2H)]·H₂O (CuHp₂DAP); and a mononuclear nickel(II) complex, [Ni(Hp₂DAP-2H)] (NiHp₂DAP). The structural and electronic properties of these complexes were elucidated through a multi-technique analytical approach, including Raman, UV-Vis, and IR spectroscopy, alongside Scanning Electron Microscopy with Energy-Dispersive X-ray Analysis (SEM-EDX) and X-Ray Diffraction (XRD). Our investigations reveal that the structural and electronic properties of these complexes are dictated by the specific metal centers. We observed the formation of a peroxo (μ-O₂) bridge in the binuclear Co(III) complex, a structural motif with direct implications for redox cycling and potential application in chemodynamic therapy (CDT) [2]. The Cu(II) complex exhibits spectral signatures characteristic of a Jahn-Teller (JT) distorted geometry. JT distortion in Cu (II) complexes is frequently discussed in the context of biomedical applications, especially anticancer agents [3], DNA – binding/cleavage [4], radiopharmaceuticals and antioxidant/SOD – mimic activities [5]. The vibrational analysis of NiHp₂DAP serves as experimental foundation for its proposed biophysical applications. Following the precedent set for related bioactive Ni(II)-Schiff base systems, we use Raman spectroscopy to verify the stable, electron-delocalized core that enables strong interactions with biological targets, as evidenced by molecular docking and binding studies [6]. These results highlight the versatility of the Hp₂DAP ligand in stabilizing diverse coordination environments and modulating metal-centered reactivity. This study provides critical foundational insights into the structure-property relationships of these systems, establishing them as promising platforms for the rational design of novel therapeutic agents.

REFERENCES

- [1] K. Alomar, M. A. Khan et al., *J. Mol. Struct.* 1250 (2002), 131836.
- [2] A. Adetoro, S. O. Idris et al., *Bull. Chem. Soc. Ethiop.* 35 (2) (2021), 425–434.
- [3] M. A. Göktürk, *Appl. Organomet. Chem.* (2024).
- [4] V. Uma, M. Kanthimathi et al., *J. Inorg. Biochem.* 100 (3) (2006), 316–322.
- [5] Q. Liao, S. C. L. Kamerlin et al., *J. Phys. Chem. Lett.* 6 (13) (2015), 2657–2662.
- [6] R. Venkatesh, T. Murugan et al., *Sci. Rep.* 16 (2026), 2256.

ORCID: J.J. 0000-0003-3440-9464, M.R. 0000-0001-6675-9763, J.M. 0000-0002-1526-3976

A role for astrocytes in Fragile X syndrome?

Danijela Bataveljic^{1,2}

(1) *Neuroglial Interactions in Cerebral Physiology, Center for Interdisciplinary Research in Biology, Collège de France, CNRS UMR 7241, INSERM U1050, Labex Memolife, PSL Research University, Place Marcelin Berthelot 11, 75005 Paris, France.*

(2) *Department of Biomedical Sciences, University of Antwerp, Universiteitsplein 1, 2610 Antwerp, Belgium*

Contact: D. Bataveljic (danijela.bataveljic@uantwerpen.be)

Abstract. Astrocytes are synaptic elements that dynamically regulate synaptic microenvironment and neuronal activity. These glial cells intimately interact with neurons at the synaptic and network level and actively regulate neuronal activity through maintenance of potassium and glutamate homeostasis. Disturbances in astrocyte properties have been implicated in various neurological disorders including neurodevelopmental disorder Fragile X syndrome (FXS). FXS is an inherited form of intellectual disability caused by the loss of the mRNA-binding fragile X mental retardation protein (FMRP) and characterized by increased neuronal excitability and behavioral defects, however the mechanisms underlying these critical dysfunctions remain unclear. In this study, we demonstrate the impairment of potassium homeostasis in FXS that results from dysfunction of astrocyte potassium channel Kir4.1 mediating uptake of potassium ions following synaptic activity. This astroglial channel is a binding target of FMRP (Figure 1), a protein that is lacking in FXS. Further relevance of Kir4.1 in the pathophysiology of FXS is demonstrated by contribution of this channel deficits to cognitive and social behavioral impairments in FXS mouse model. Targeting Kir4.1 channel through viral delivery into astrocytes rescues normal astrocyte potassium uptake, and behavioral phenotypes of FXS. By focusing on the role of astrocytes in FXS, we provide compelling evidence for Kir4.1 dysfunction as a major contributor to compromised potassium homeostasis and behavioral deficits and we propose astroglial Kir4.1 channel as a potential therapeutic target for FXS.

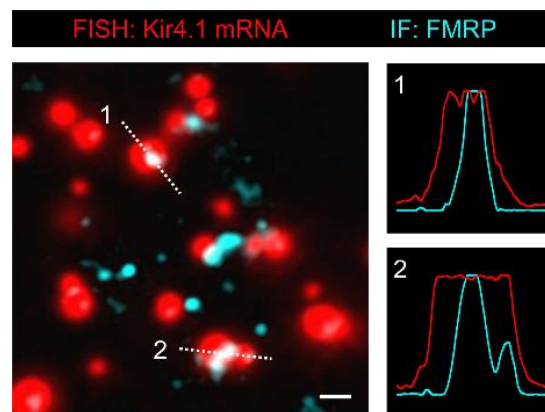


Figure 1. Kir4.1 mRNA is a binding target of FMRP. Confocal image of FISH detected Kir4.1 mRNA (red) and immunofluorescently labeled FMRP (cyan). Line profiles of individual fluorescent signals along white lines. Scale bar 1 μ m. Adopted from [1].

REFERENCES

[1] D. Bataveljic, H. Pivonkova et al., *Nat Commun.* **15** (2024), 3583.

ORCID: D.B. 0000-0002-9593-8231

Scalability of splitters based on waveguide arrays

Kolja Bugarski¹, Dimitris V. Bellas², Aleksandra Maluckov¹, Goran Z. Mašanović³, Jovana Petrović¹

(1) *Vinca Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Serbia*

(2) *Center for Interdisciplinary Research and Innovation Aristotle University of Thessaloniki (CIRI-AUTH), Greece*

(3) *Optoelectronics Research Centre, University of Southampton, UK*

Contact: K. Bugarski (kolja.bugarski@vin.bg.ac.rs)

Abstract. Photonic integrated circuits (PICs) are a promising route towards the next generation of classical and quantum information technologies [1, 2]. An important challenge before their widespread implementation is scaling to a competitive footprint and high data transfer rate [3]. This translates into solving the problems of crosstalk between photonic components and energy loss, both exacerbated by minimization.

Here, we present the design of a miniature 1:N splitter based on linearly coupled waveguide arrays in silicon on insulator (SOI). Previously, we demonstrated the proof of principle in waveguides realized by femtosecond laser writing in glass [4]. The main difference between these two platforms is the contrast in refractive indices of the waveguide core and cladding. SOI has 2 orders of magnitude higher contrast, which allows for sub-micron interwaveguide spacing while maintaining coupling only between nearest neighbours and single-mode guiding. Our finite-difference-time-domain simulations in Lumerical show promising prospects for realizing small-footprint low-loss splitters. A few-micrometer splitter width requires waveguide fan-out to tens of micrometers needed for coupling to external sources and detectors and, hence, the multiscale simulation. We will discuss these challenges and solutions and offer insights into the mask design as the final step before fabrication.

Further developments include incorporating non-nearest-neighbour coupling to achieve the ultimate footprint scaling for single-mode waveguides.

REFERENCES

- [1] Yikai Su et al., *ACS Photonics* 10 (2023) 2020–2030
- [2] Andrew Netherton et al., *Photon. Res.* 12 (2024) A69-A86
- [3] Laurent Labonté et al., *PRX Quantum* 5 (2024) 010101
- [4] P. Vildoso, et al., *Opt. Express* 31 (2023) 12703–12716

ORCID: K.B. 0000-0002-4924-1564, A.M. 0000-0002-6474-360X, J.P. 0000-0002-1002-241X, G.Z.M. 0000-0003-2954-5138, D.V.B. 0000-0003-4085-6703

Coherent Anti-Stokes Raman Scattering (CARS) Microscopy as a Smart Tool for Nano/Micromotors Research

Tijana Miseljic¹

(1) DTU Health Tech, Technical University of Denmark, Ørstedsgade, 2800 Kgs. Lyngby, Denmark

Contact: T. Miseljic (tijma@dtu.dk)

Abstract. Coherent Anti-Stokes Raman Scattering (CARS) microscopy is a powerful, label-free imaging technique that overcomes the limitations of conventional Raman spectroscopy and enables chemically selective, real-time, high-resolution imaging. Nano/micromotors are artificial nano- and microscale systems capable of converting external energy sources into autonomous motion [1]. In nano/micromotor research, CARS offers unique dual functionality: it enables both near-infrared (NIR) laser-triggered nano/micromotor activity [2] and simultaneous chemical imaging of cargo and structural components [3]. Using two synchronized NIR laser beams, CARS microscopy enables deep penetration with reduced scattering, minimized autofluorescence, and photobleaching avoidance, making it suitable for dynamic nano/micromotor systems [4]. Recent studies demonstrate that CARS can selectively detect drug-loaded nano/micromotors while remaining insensitive to unloaded structures and can be integrated with NIR-driven plasmonic systems to activate and monitor micromotor motion in situ [5]. These capabilities position CARS microscopy as a smart photonic tool for both actuation and imaging of nano/micromotors, providing insights into propulsion mechanisms and functional performance that are inaccessible with conventional optical techniques.

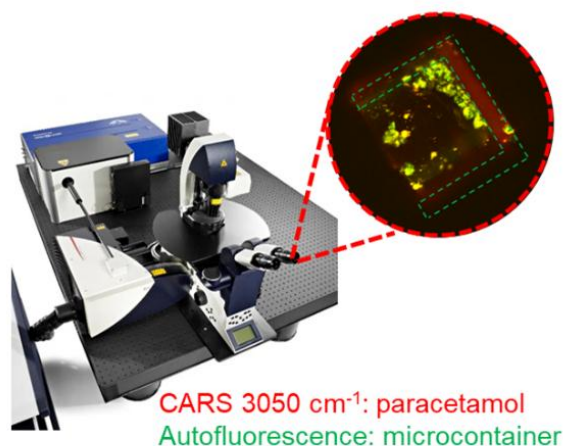


Figure 1. Schematic overview of the coherent anti-Stokes Raman scattering (CARS) microscopy system.

REFERENCES

- [1] M. Fernández-Medina, M. A. Ramos-Docampo et al., *Adv. Funct. Mater.* 30 (2020), 1908283.
- [2] T. Maric, S. Atladóttir et al., *Appl. Mater. Today* 27 (2022), 101418.
- [3] T. Maric, V. Adamakis et al., *Small* 19 (2023), 2206330.
- [4] C. Krafft, A. A. Ramoji et al., *J. Biophotonics* 2 (2009), 303–312.
- [5] T. Maric, A. Løvind et al., *Adv. Healthcare Mater.* 12 (2023), 2203018.

ORCID: T.M. 0000-0002-6847-251X

Composite diamond particles with various functionalization for biological applications

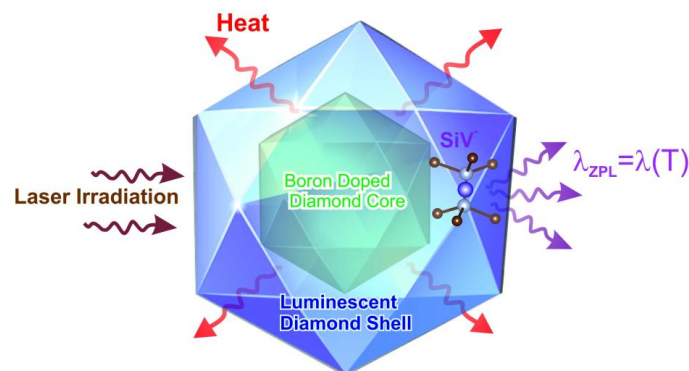
Kirill V. Bogdanov¹, Taisiia E. Didukh¹, Sergey A. Grudinkin², Alexander V. Baranov¹

(1) ITMO University, 49 Kronverksky pr, Saint Petersburg 197101, Russia

(2) Ioffe Institute, Polytechnicheskaya St., 26, 194021, St. Petersburg, Russian Federation

Contact: K.V. Bogdanov (kirw.bog@gmail.com)

Abstract. The development of modern multifunctional technologies for biomedical applications is one of the most important tasks in global science. Therefore, the development of new, multifunctional, low-toxicity therapeutic agents that can be delivered to the affected area and provide remotely controlled therapy is a pressing issue in modern biological applications. The primary advantage of nanodiamonds lies in their biocompatibility and the possibility of surface functionalization. In this study, we present the development of a technology for the creation of a new composite material based on CVD diamond nano- and submicroparticles with a core/shell structure, in which the inner region (the "core"), heavily doped with boron, is effectively heated by absorbed laser radiation [1] and heats the outer transparent diamond layer (the "shell") with SiV and GeV color centers emitting intense narrow lines of zero-phonon luminescence (ZPL) with a temperature-dependent wavelength in the region of 738 and 602 nm, respectively [2]. The particles were synthesized using chemical vapor deposition with a hot filament [3]. The data on the temperature dependences of SiV and GeV color centers in particles consisting entirely of a shell luminescent phase and for particles created on the basis of a highly borated core, as well as their comparative analysis, will be presented. These various functionalization have allowed the optimization of both the structural and luminescent properties of the nanoparticles to enhance absorption efficiency and improve the temperature sensitivity of the color center parameters [4].



Schematic image of hybrid core/shell diamond particle with a boron-doped core absorbing laser light and a diamond shell with luminescent SiV and GeV centers.

The work was supported by the Russian Science Foundation, grant No. 25-15-00068.

REFERENCES

- [1] A.M. Vervald, (et.al) *Sci. Eng.* 2020, 6 (8), 4446-4453.
- [2] L. Golubewa, (et.al). *Adv. Optical Mater.* 2022, 10, 2200631.
- [3] S.A. Grudinkin, (et.al) *Phys. Solid State.* 2022, 64 (10), 1506-1511.
- [4] Grudinkin, S. A., (et al.). *Nanomaterials.* 2023, 13(24), 3124.

ORCID: B.K. 0000-0003-4243-1354

Post-Exercise Cardiac Recovery as a Multiscale Dynamical Process

Danka B. Stojanović¹, Marjan Miletić¹, Marija D. Ivanović¹, Ljupčo Hadžievski¹, Jovana Petrović¹, Aleksandra Maluckov¹

(1) Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

Contact: D.B. Stojanovic (dankas@vin.bg.ac.rs)

Abstract. Nonlinear dynamics and chaos-based signal analysis provide a powerful framework for probing physiological regulation beyond conventional linear descriptors. In particular, post-exercise recovery represents a controlled, reproducible dynamical transition through which the adaptability and coupling of cardiovascular and autonomic subsystems can be examined. We investigate recovery dynamics using multifractal spectra (MFS) of simultaneously recorded multimodal cardiovascular signals—electrocardiography (ECG), photoplethysmography (PPG), seismocardiography (SCG), and phonocardiography (PCG)—as illustrated in Fig. 1. Thirty-second recordings from 28 healthy volunteers, acquired at rest and during post-exercise recovery from the SensSmartTech database, were analyzed. MFS features were extracted to characterize scale-dependent fluctuations arising from nonlinear interactions across modalities. To assess the discriminative power of these features, 5 supervised learning algorithms—Logistic Regression, Support Vector Machine with RBF kernel, k-Nearest Neighbours, Decision Tree, and Random Forest—were employed to classify recovery states.

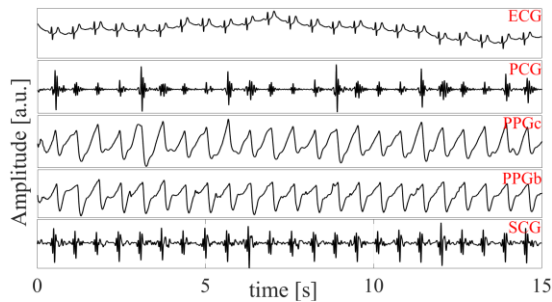


Figure 1. Snapshot of raw post-running signals recorded simultaneously by the polycardiograph: ECG, PCG, carotid PPG (PPGc), brachial PPG (PPGb) and SCG.

Two complementary feature sets were evaluated with a target to classify subjects into three groups defined by the speed of recovery: $\mathbf{F}_{\text{change}}$, capturing long-term dynamical adaptation between resting and post-exercise states, and \mathbf{F}_{half} , quantifying recovery at a standardized half-recovery time. Our results demonstrate a reliable classification using a compact set of MFS features, even with limited data duration, and a clear benefit from inclusion of nonlinear interactions. They indicate that the post-exercise recovery is governed by coupled, multiscale processes spanning multiple physiological subsystems. The integration of multifractal analysis with multimodal sensing thus provides robust, physically interpretable markers of recovery dynamics and offers a promising route toward nonlinear diagnostics of cardiovascular function.

Funding for this work has been provided by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-136/2025-03/200017) and by support of the Science Fund of the Republic of Serbia, Grant No. 7754338, Multi-SENSor System and ARTificial intelligence in service of heart failure diagnosis – SensSmart.

REFERENCES

- [1] P. C. Ivanov, *Nature* **399** (1999) 461–465.
- [2] L. Goldberger, D. R. Rigney, B. J. West, *Yale Journal of Biology and Medicine* **63**, (1990) 221–235.
- [3] A. Lazovic et al, *Sci. Data* **12** (2025) 1452.
- [4] A. Maluckov et al, *Chaos* **36** (2026) 1-11.

ORCID: D.S. 0000-0002-7178-1970, M.M 0000-0002-8476-4141, M.I. 0000-0002-1152-4171, Lj. H. 0000-0002-3955-628X, J. P. 0000-0002-1002-241X, A.M. 0000-0002-6474-360X

Evaluation and impact assessment of Horizon Europe project BioQantSense

Marina Lekić¹, [Brana Jelenković](#)¹

(1) *Institute of Physics Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*

Contact: B. Jelenkovic (branaj@ipb.ac.rs)

Abstract. The Horizon Europe project, Twinning for Excellence of the Serbian Research Center for Quantum Biophotonics (BioQantSense), has now reached the conclusion of its three and a half years of activity. We will evaluate the research and management outcomes achieved during the project.

In the initial stages of BioQantSense, the primary focus was on the transfer of knowledge and expertise from the project partners to the coordinating institution. These efforts centered on the fields of classical and quantum biophotonics, laying a strong foundation for the center's future research activities. As the project advanced, particularly in the final year, the emphasis was toward utilizing the acquired knowledge. Collaborative efforts were directed at developing suitable experiments that would reflect the project's core aims and drive scientific inquiry in the designated areas.

The realization of BioQantSense's objectives includes significant advancements in scientific knowledge and research within quantum and nonlinear optics. Additionally, the project has led to notable progress in management and administrative practices. The dissemination and exploitation of the results achieved have been a central aspect, ensuring that the outcomes of BioQantSense contribute widely to the scientific community and beyond.

Acknowledgement. This work was supported by the Horizon WIDERA 2021-ACCESS-03-01 grant, #101079355 "BioQantSense".

FBG based optical load cell: Proof of Concept experience

Ana Joža¹, Jovan Bajić¹, Miroslav Dramićanin¹, Milan Kovačević²

(1) Faculty of Technical Sciences, University of Novi Sad, Trg Dositeja Obradovića 6, 21000 Novi Sad, Serbia

(2) Faculty of Science, University of Kragujevac, Radoja Domanovića 12, 34000 Kragujevac, Serbia

Contact: A. Joža (anajoza@uns.ac.rs)

Abstract. Recently, there has been increasing interest in the development of optical load cells for measurement of force, mass and pressure [1-3]. Optical load cells can overcome the limitations of commonly used electrical load cells with resistive strain gauges in demanding applications, such as environments with high electromagnetic interference, high humidity and corrosion, for remote, multipoint and distributed measurements. Within the INFIBRA project funded by the Science Fund (SF) of the Republic of Serbia within the Proof of Concept (PoC) program, a new industrial grade optical load cell based on fiber Bragg gratings (FBG) was developed. Over a period of 12 months, the idea of this FBG load cell was expected to be specified in detail, necessary equipment to be procured and the concept to be proven, thus reaching technology readiness level 3 (TRL3). An important aspect of this program was the arrangement of intellectual property ownership to enable potential future commercialization of the product. In this paper, the authors presented their experience with this PoC project and the results obtained. The S-beam load cell profile was selected since it can be used for both compression and tension measurements. At the most strain-sensitive locations of the S-beam, fiber Bragg gratings in the form of FBG array are mounted in the same way as the resistive strain gauges traditionally used within commercial load cells. After mechanical and optical modelling and simulation, several optical load cell profiles and FBG array configurations were specified and fabricated. Subsequently, the project team members assembled several FBG load cell configurations (Fig. 1) and successfully performed laboratory tests of these FBG load cells under various stress and temperature conditions, thereby exceeding the expected target by reaching TRL4 technology readiness level. Finally, opportunities and directions for future work are outlined.

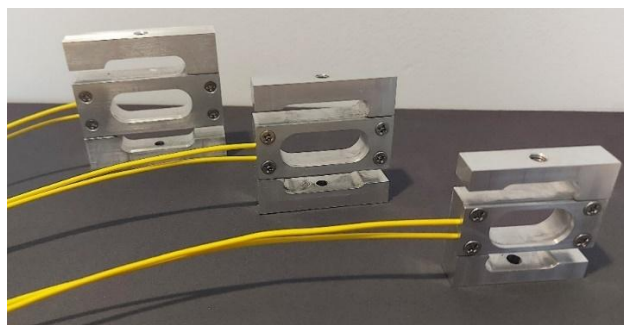


Figure 1. Assembled optical load cells rated for 2000N, 1000N and 500N (left to right).

REFERENCES

- [1] A. Gautam, A. Kumar et al., *IEEE Sensors Journal* **20** (2020), 4207 - 4214.
- [2] C. Li, Y. Wang et al., *Sensors and Actuators A: Physical* **154** (2009), 12 - 15.
- [3] G. Ma, N. Mao et al., *Sensors* **16** (2016), art. 922.

ORCID: A.J. 0000-0002-0768-6864, J.B. 0000-0002-8823-5423, M.D. 0000-0002-9079-0864, M.K. 0000-0001-7643-9886.

Wavelength Demultiplexers Based on Self-Imaging in Optical Lattices with Length-Modulated Waveguides

Mirjana G. Stojanović¹, Kolja Bugarski ^{2,1}, Aleksandra Maluckov¹, Jovana Petrović¹

(1) *Vinča Institute of Nuclear Sciences, National Institute of Republic of Serbia, University of Belgrade, P.O. Box 522, 11001 Belgrade, Serbia*

(2) *School of Electrical Engineering, University of Belgrade, Serbia*

Contact: M. G. Stojanović (mirjana.stojanovic@vin.bg.ac.rs)

Abstract. We have proposed a wavelength demultiplexer based on wavelength-dependent self-imaging in linearly coupled optical lattices, implemented using a simple and compact photonic lattice configuration [1]. Straight waveguides ensure low propagation losses, while intuitive control of the coupling parameters allows precise tuning of both the output wavelength and the operational bandwidth. An experimental proof of concept is provided through fabrication of the demultiplexers in borosilicate glass using femtosecond laser writing techniques [2, 3].

The wavelength separation is achieved via self-imaging and perfect state transfer of the input optical field during propagation through a lattice with length-modulated waveguides. Specifically, longer wavelengths revive in the input waveguide, whereas shorter wavelengths are fully transferred to the opposite output port. However, this approach allows for dichroic separation only.

To extend the splitting capability to multiple wavelengths, we introduce a modified structure with waveguide lengths as additional parameters. Only the input waveguide and its nearest neighbor are of equal lengths, while successive waveguides are gradually shortened. We will present the design principle, numerical simulations and performance evaluation of 3- and 4-wavelength demultiplexers.

REFERENCES

- [1] M. G. Stojanović, P. Vildoso, K. Bugarski, P. M. Parra, A. Maluckov, R. A. Vicencio, J. Petrović, J. Opt. **27** (2025), 055801.
- [2] D. Guzmán-Silva, G. Cáceres-Aravena, R. A. Vicencio, Phys. Rev. Lett. **127** (2021), 066601.
- [3] A. Szameit, S. Nolte, J. Phys. B: At. Mol. Opt. Phys. **43** (2010), 163001.

ORCID: M.G. S. 0000-0002-4376-7610, K.B. 0000-0002-4924-1564, A.M. 0000-0002-6474-360X, J.P. 0000-0002-1002-241X

Quantum sensing with photon pairs

Frank Setzpfandt^{1,2}

(1) *Institute of Applied Physics, Abbe Center of Photonics, Friedrich Schiller University Jena, Albert-Einstein-Str. 15, 07745 Jena, Germany*

(2) *Fraunhofer Institute of Applied Optics and Precision Mechanics IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany*

Contact: F. Setzpfandt (f.setzpfandt@uni-jena.de)

Abstract. Quantum sensing with photon pairs is a rapidly growing field of science, which uses the quantum nature of light to develop methods with improved properties for imaging, spectroscopy, and polarization measurements [1, 2]. One of the key promises of these quantum measurement schemes is to improve sensing at longer wavelengths, which can give access to chemical information of investigated samples, while also using the benefits enabled by quantum entanglement.

In my talk I will discuss a method for spectroscopy with undetected photons that can measure in the mid-infrared spectral range around 6 μm while only using a silicon camera sensor for detection. For making this practically usable, we developed a technique to compensate for dispersion induced phase shifts that previously limited the measurement contrast [3].

For imaging with undetected photons, we developed a scanning imaging technique that enables to overcome limitations in the achievable spatial resolution of wide-field techniques. This as implemented at a wavelength of 2.4 μm [4] and successfully applied to biological specimen.

Finally, I will also talk about our efforts to implement polarization sensing using polarization-entangled photon pairs, for which we demonstrated the ability to distinguish between different monolayers of cells [5, 6].

REFERENCES

- [1] M. Gilaberte Basset, F. Setzpfandt, F. Steinlechner, E. Beckert, T. Pertsch, and M. Gräfe, *Laser Photon. Rev.* 13, 1900097 (2019).
- [2] L. Zhang, C. Zou, Y. Wang, F. Setzpfandt, and V. R. Besaga, *Chinese Optics Letters* 23, 092701 (2025).
- [3] M. Kumar, D. Dupish, P. Kumar, L. Zhang, S. Lung, V. Besaga, T. Pertsch, F. Setzpfandt, *APL Photonics* 10, 106121 (2025).
- [4] J. R. León-Torres, V.-L. Dosan, M. M. Ćurčić, A. Lagarrigue, F. Setzpfandt, M. Gräfe, V. F. Gili, *Laser & Photonics Reviews*, e02356 (2025).
- [5] V. R. Besaga, L. Zhang, A. Vega, P. S. Chauhan, T. Siefke, F. Steinlechner, T. Pertsch, A. A. Sukhorukov, F. Setzpfandt, *APL Photonics* 9, 041301 (2024).
- [6] L. Zhang, V. R. Besaga, P. Rühl, C. Zou, S. H. Heinemann, Y. Wang, F. Setzpfandt, *Journal of Biophotonics*, e202400018 (2024).

ORCID: F.S. 0000-0002-7919-8181

Autofluorescence label-free high-contrast imaging of tumor margins in freshly excised gastro-intestinal biopsies

Dafne Suraci¹, Luca Tirloni², Joao L. Lagarto³, Antonio Taddei^{2,4}, and Riccardo Cicchi^{1,5}

(1) National Institute of Optics, National Research Council (CNR-INO), 50125, Florence, Italy

(2) Hepatobiliopancreatic Surgery, Careggi University Hospital, 50134, Florence, Italy

(3) Biophotonics Platform, Champalimaud Foundation, 1400-038 Lisbon, Portugal

(4) Department of Experimental Clinical Medicine, University of Florence, 50134, Florence, Italy

(5) European Laboratory for Non-linear Spectroscopy (LENS), 50019, Sesto Fiorentino, Italy

Contact: R. Cicchi (riccardo.cicchi@cnr.it)

Abstract. Liver cancer is a global health challenge, and its incidence is growing worldwide, with more than 1 million cases per year by 2025. While hepatocellular carcinoma (HCC) is the most common form of liver cancer, hepatic metastases of colorectal carcinoma (CRC) are the natural disease evolution in almost 50% of patients with CRC. For both HCC and CRC liver metastases, surgical resection represents the only chance of long-term survival [1]. In this context, a label-free optical diagnostic and/or surgical guidance tool would be highly suitable to reduce possible positive margin and improve the patient disease outcome. In this study, we used a custom-made autofluorescence lifetime fiber-based imaging instrumentation [2] to provide real-time discrimination of tumor from perilesional tissues in freshly excised liver samples. The proposed approach allowed discriminating tumor from perilesional tissue, reporting the fluorescence lifetime decay of cellular metabolic markers and enabling the delineation of tumor against healthy margin in different clinical cases of gastrointestinal tissues [3]. The approach was validated on a larger statistic by examining around 50 surgical specimens of both HCC and CRC hepatic metastases, demonstrating that this approach is a powerful method for delineating tumor borders as well as for differentiating HCC from CRC metastases to the liver [4]. The obtained results, together with the capability to acquire and process images in real time under bright background, enables our methodology to be translated into surgical scenario for label-free tissue diagnostics and surgical guidance.

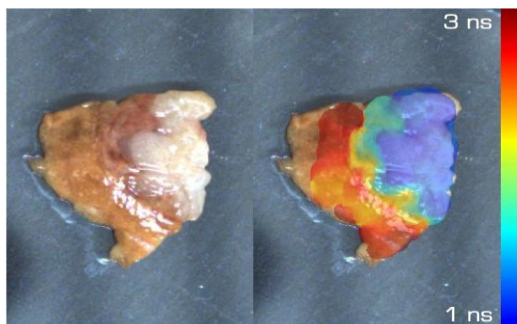


Figure 1. A white light image (left) of a fresh biopsy of a hepatocellular carcinoma specimen, together with the corresponding autofluorescence lifetime map, presented as augmented-reality image (right).

REFERENCES

- [1] Q. Wang, H.J. Li, X.M. Dai, Z.Q. Xiang, and Z. Zhu, *Int. J. Surgery* **105** (2022)
- [2] J. L. Lagarto, V. Shcheslavskiy, F.S. Pavone, and R. Cicchi, *J. Biophoton* **13** (2020)
- [3] D. Suraci, E. Baria, L. Tirloni et al., *J. Biophoton* **17** (2024)
- [4] D. Suraci, L. Tirloni, C. Gatto et al., *Biomed. Opt. Express* **16** (2025)

ORCID: D.S. 0000-0002-4140-5413, L.T. 0000-0002-6060-2172, J.L.L. 0000-0001-9396-8923, A.T. 0000-0003-2963-4085, R.C. 0000-0002-2583-6694

Reconfigurable optical and magnetic unclonable functions

Sara Nocentini^{1,2,3}

(1) *Istituto Nazionale di Ricerca Metrologica (INRiM), Strada delle Cacce 91, Turin, 10135 Italy;*

(2) *European Laboratory for Nonlinear Spectroscopy (LENS), Via Nello Carrara 1, 50019, Sesto Fiorentino (FI), Italy;*

(3) *CNR-INO, Via Nello Carrara 1, 50019, Sesto Fiorentino (FI), Italy*

Contact: S. Nocentini (s.nocentini@inrim.it; nocentini@lens.unifi.it)

Abstract. In the current AI era, privacy and security against machine learning attacks is an imperative request. While cryptographic keys generated by computer algorithm need to be stored in volatile memories thus being vulnerable to cyber-attacks, unclonable physical systems under a proper interrogation (physical stimulus) provides complex, secure and on-the-fly extraction of cryptographic keys with a greater security [1]. The interest in the field is growing exponentially as well as the number of publications on physical unclonable functions or PUFs. In this presentation, I will discuss two classes of PUFs, optical and magnetic PUFs with a focus on the possibility to enhance their security via a proper reconfiguration mechanism [2,3]. While static PUFs provide stable responses to selected challenges, reconfigurable PUFs allow for a refresh mechanism of the physical function in a not reversible way. We can thus obtain new sets of challenge-response pairs providing a secure authentication process in case of malicious attack.

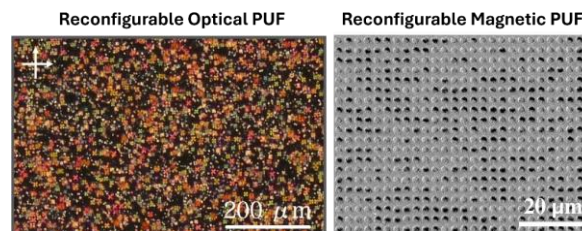


Figure 1. Left panel. Polarized optical microscope image of an optical reconfigurable PUF made by polymer dispersed liquid crystals. Right panel. Magnetic optical Kerr effect microscope image of an array of FeGa unclonable magnetic dots. Both systems provide reconfiguration mechanism.

By using liquid crystals, we studied the reconfigurability properties of an optical PUF via a speckle-based statistical analysis based on correlation, fractional hamming distance and holographic measurement in collaboration with Institute of Physics Belgrade within the project BioQantSense [2]. On the other hand, leveraging remanence and anhysteretic states of a 2D FeGa microdot array, we achieved a dual-mode operation switching between reproducible and reconfigurable responses of a magnetic PUF [3]. These two examples will allow me to deepen the PUF security and adaptability across diverse applications.

REFERENCES

- [1] S. Nocentini, U. Rührmair, et al., *Nat. Mater* **23**, 3 (2024), 369-376.
- [2] S. Salvestrini, F. Maestri, *APL Photonics* (2026), Accepted.
- [3] A. Magni, G. Barrera, et al., *Adv. Funct. Mater.* **35**, 52 (2025), e16376.

Part of these results have been obtained within the BioQantSense project, EU Horizon Widera 2021-ACCESS- 03-01, GA ID 101079355.

ORCID: S.N. 0000-0003-2392-9077

Nonlinear carrier-photon dynamics in semiconductor-based activation units for all-optical neural networks

Dejan Gvozdić¹, Jasna Crnjanski¹, Mladen Banović¹, Petar Atanasijević¹, Marko Krstić¹

(1) School of Electrical Engineering – University of Belgrade, Bulevar kralja Aleksandra 73b, 11000 Belgrade, Serbia

Contact: D. M. Gvozdić (gvozdic@etf.bg.ac.rs)

Abstract. The explosive growth of Big Data, IoT, and AI workloads is driving the demand for specialized computing hardware with greatly improved energy efficiency. Although Koomey’s law captured past efficiency gains, this trend has slowed, revealing an emerging energy-efficiency wall [1] for conventional electronic processors. Photonic computing has therefore attracted significant interest due to its high bandwidth, ultra-low latency, and potential for improved energy efficiency, while simultaneously offering a natural platform for the realization of optical artificial neural networks capable of massively parallel and high-throughput information processing [2, 3]. However, the weakly interacting nature of photons poses a fundamental challenge for implementing efficient nonlinear activation functions, which are essential for neural network expressivity. Many photonic neural network implementations rely on opto-electro-optical activation, where optical signals are converted to the electrical domain. While effective, this approach undermines the inherent advantages of photonics, limiting scalability, bandwidth, and energy efficiency. Similarly, passive photonic approaches cannot provide strong, compact, and energy-efficient nonlinear activation. In contrast, all-optical solutions based on active semiconductor devices, exploiting intrinsic carrier-photon interactions, offer a viable route toward scalable neural network hardware. Such devices can directly realize nonlinear activation functions with sub-picojoule-level energy consumption, high-speed operation, and the potential for reconfigurability [4, 5]. In this work, we review the key physical mechanisms in active semiconductor components that enable the realization of nonlinear activation functions and discuss how reconfigurable and energy-efficient nonlinear activation functions can be employed in selected classes of optical artificial neural network architectures [2, 3].

Acknowledgment. The research was supported by Science Fund of the Republic of Serbia (#7750121, ORCA-LAB), and by Serbian Ministry of Science, Technology and Innovation (451- 03-65/2024-03/200103). The research was partially conducted in the premises of the Palace of Science, Miodrag Kostić Endowment.

REFERENCES

- [1] J. G. Koomey et al. *IEEE Annals of the History of Computing* 33(3), 46–54 (2011).
- [2] J. V. Crnjanski, I. Teofilović, M. M. Krstić, and D. M. Gvozdić, *Opt. Lett.* 49, 1153 (2024).
- [3] M. Ž. Banović, J. V. Crnjanski, M. M. Krstić, and D. M. Gvozdić, *J. Lightwave Technol.* 42, 7785 (2024).
- [4] J. Crnjanski, M. Krstić, A. Totović, N. Pleros, D. Gvozdić, *Opt. Lett.* 46, 2003–2006 (2021).
- [5] M. Ž. Banović et al., *APL Photonics*, 10 (10): 106101, (2025).

ORCID: D.G. 0000-0003-0917-5280, J.C. 0000-0003-0685-4093, M.B. 0009-0001-1843-6326, P.A. 0000-0001-7596-0266, M.K. 0000-0001-5284-4959

Optical limiter and isolators in nonlinear multilayer photonic systems

Francesco Riboli^{1,2}

(1) *Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche, 50019 Sesto Fiorentino, Italy*

(2) *European Laboratory for Nonlinear Spectroscopy (LENs), 50019 Sesto Fiorentino, Italy*

Contact: F. Riboli (francesco.riboli@ino.cnr.it)

Abstract. Parity–time (PT) symmetry in optics has emerged as a powerful concept for controlling how light propagates through optical systems. In this talk, I present an optical limiter based on a multilayer coupled optical cavity that supports PT-symmetric, reflectionless modes [1]. The limiting behaviour occurs when PT symmetry is broken by light-induced changes in one of the cavities, causing a strong modification of the optical response. The device consists of a three-mirror resonator made of alternating layers of ZnS and cryolite. Its self-activating optical limiting behaviour is demonstrated using single 6 ns laser pulses at a wavelength of 532 nm and is supported by thermo-optical simulations. At low light levels, the multilayer structure exhibits a flat, high-transmission passband. As the input fluence increases, laser heating and the thermo-optic effect in ZnS detune the cavity, leading to PT-symmetry breaking. As a result, the structure rapidly becomes highly reflective, effectively protecting itself from laser-induced damage. In addition, I will present recent results toward the realization of an optical isolator by exploiting disordered nonlinear multilayer photonic systems.

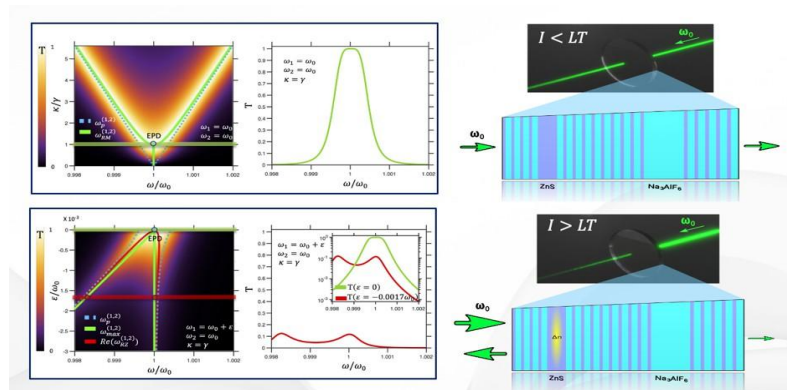


Figure 1. **(top)** Transmittance $T(\omega/\omega_0)$ in the parameter space of κ/γ . $\kappa \geq \gamma$ corresponds to the exact PT-symmetric phase, where the RMs are formed. At frequencies $\omega_{\text{RM}}^{(1,2)}$, $T = 1$ (solid green lines). At the spontaneous PT-symmetry breaking point, $\kappa = \gamma$, both the frequencies $\omega_{\text{RM}}^{(1,2)}$ and the corresponding eigenmodes coalesce, forming an EPD at $\omega_{\text{EPD}} = \omega_0$ (open circle). **(bottom)** Explicit PT-symmetry breaking due to the mode detuning $\omega_1 = \omega_0 + \varepsilon$; (e) (colormap) transmittance $T_{\kappa=\gamma}(\omega/\omega_0)$ in the parameter space of ε/ω_0 . The dashed blue lines indicate the resonance frequencies $\omega_p^{(1,2)}$. The solid green lines denote the peak transmittance frequencies $\omega_{\text{max}}^{(1,2)}$.

REFERENCES

- [1] F. Riboli et al., *Optical limiter based on PT-symmetry breaking of reflectionless modes*, *Optica*. **10**, 10 (2024), 1302-1309.

ORCID: F.R. 0000-0002-5553-9762

All-glass atomic vapour cells fabricated by laser-assisted bonding

D. Nodop², T. Kügler¹, F. Wittkämper¹, T. Scholtes¹, J. Rücker², and R. Stolz¹

(1) *Leibniz Institute of Photonic Technology, Albert-Einstein-Straße 9, 07745 Jena, Germany*

(2) *Günter Köhler Institute for Joining Technology and Materials Testing, Ernst-Ruska-Ring 3, 07745 Jena, Germany*

Contact: T. Scholtes (theo.scholtes@leibniz-ipht.de)

Abstract. Atomic vapour cells are fundamental components in many modern quantum systems and sensors, including optically pumped magnetometers, atomic clocks, laser frequency references, quantum state storage devices, and electrometers based on Rydberg atoms [1,2].

Traditionally, glass-blown vapour cells have been employed, utilizing specialized organic wall coatings to preserve atomic spin states – a process that, even today, relies heavily on empirical expertise. The development of microfabricated vapour cells based on wafer-scale anodic bonding enabled the mass production of nominally identical cells. Additionally, it facilitated their functionalization using thin-film processes for integrating components such as electrodes, magnetic field coils, electrical heaters, antireflective coatings, and optical mirrors. However, due to the process temperature, standard anodic bonding is incompatible with organic thin films required for spin-state preservation and imposes limitations on cell design.

Here, we present a novel approach to vapour cell fabrication based on laser-assisted bonding of glass. Hermetic sealing is achieved through optical contact bonding of glass parts with minimal surface roughness, performed under vacuum or in an inert buffer gas atmosphere. Subsequent laser-assisted bonding ensures long-term connection stability. Since the laser-assisted bonding is carried out at room temperature with minimal and localized heating of the sample and without the need for application of additional electrical voltages and fields, the range of compatible thin-film processes for cell functionalization is significantly expanded. Furthermore, this method enables the fabrication of all-glass cells and cell arrays with standardized geometries, offering, for example, full optical access to all six faces of a cubic cell. Furthermore, this method enables the use of glass types that are incompatible with anodic bonding.

Acknowledgements: We gratefully acknowledge financial support from the Free State of Thuringia from the European Social Fund Plus under funding code 2023 FGR 0072 (StaGlaOPM) and from the Federal Ministry of Research, Technology and Space (BMFTR) of Germany under Grant No. 13N16421 (QGrad).

REFERENCES

- [1] J. Kitching, *Appl. Phys. Rev.* 5, 031302 (2018).
- [2] J. Kitching, J. P. Shaffer, D. Budker, *Optica* 12, 2008-2022 (2025).

ORCID: D.N. 0000-0003-2595-2377, T.K. 0009-0007-9825-295X, F.W. 0009-0002-1663-8255, T.S. 0000-0001-6121-2574, J.R. N/A, R.S. 0000-0002-5629-4672

Quantum Noise Limited Temperature-Change Estimation for Φ -OTDR Employing Coherent Detection

Darko Zibar¹

(1) *DTU Electro, Technical University of Denmark, Ørstedes plads, Building 343, DK-2800, Kgs. Lyngby, Denmark*

Contact: D. Zibar (dazi@dtu.dk)

Abstract. The quantum limit is a fundamental lower bound on the uncertainty when estimating a parameter in a system dominated by the minimum amount of noise (quantum noise). For the first time, we derive and demonstrate the quantum limit for temperature-change estimation for coherent phase-OTDR sensing systems. By modeling Rayleigh backscattering and quantum noise sources, we show that phase estimation approaches the quantum limit, leading to a temperature uncertainty scaling inversely with signal-to-noise ratio (SNR) and sensing length. Our results establish a benchmark for the ultimate precision in coherent phase OTDR sensing systems across typical SNRs of 0-20 dB.

Photon–plasmon interactions in active whispering gallery mode microresonators on plasmonic substrates

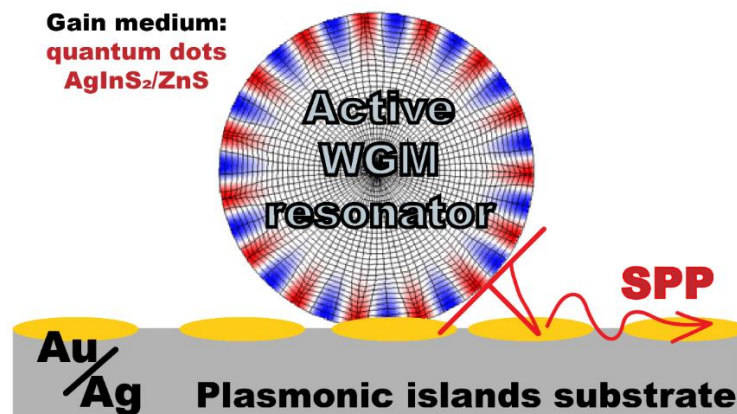
Tkach Anton Pavlovich¹, Molodcov Maksim Sergeevich¹, Strelkova Kseniia Vadimovna¹,
Bogdanov Kirill Vadimovich¹

(1) ITMO University, 49 Kronverksky pr, Saint Petersburg 197101, Russia

Contact: A.P. Tkach (toni.tkach95@gmail.com)

Abstract. Active whispering gallery mode (WGM) microresonators are a promising platform for studying light–matter interaction at the microscale due to their ability to support high-Q optical modes and enhance spontaneous emission of embedded luminophores. Hybridization of such dielectric microresonators with plasmonic nanostructures offers additional mechanisms for controlling the spectral and temporal characteristics of the emitted light through localized surface plasmon coupling.

This work focuses on hybrid microresonators based on polystyrene microspheres coated with AgInS₂/ZnS quantum dots and placed on metallic (gold and silver) nanostructured substrates separated by a controlled dielectric spacer. The broad and stable photoluminescence spectrum of the AgInS₂-based gain medium [1] enables the investigation of both resonant and non-resonant excitation regimes relative to plasmonic modes. A combined optical analysis is performed, including the study of WGM spectral features, quality factors, and emission lifetimes under varying plasmonic coupling conditions. The obtained results provide new insight into photon–plasmon interaction mechanisms in active microresonators and highlight the potential of such hybrid structures for nanoscale optical emitters [2], photonic tags [3], and integrated sensing elements [4].



Schematic image of active WGM resonator on gold and silver island substrate.

This research was funded by the Russian Science Foundation (Agreement 23-72-10010).

REFERENCES:

- [1] T.S. Ponomaryova, (et al.). *J. Anal. Chem.* **2022**, *77* (4), 402-409.
- [2] A.P. Tkach, (et al.). *Opt. Laser Technol.* **2024**, *179* (1), 111359.
- [3] A.P. Tkach, (et al.). *J. Phys.: Conf. Ser.* **2025**, *2978* (1).
- [4] M.R. Foreman, (et al.). *Adv. Opt. Photon.* **2015**, *7* (2), 168-240.

ORCID: A.T. 0000-0003-3370-6248, M.M. 0009-0007-0296-5948, K.S. 0009-0001-2231-9130, K.B. 0000-0003-4243-1354

Photothermal Conversion of Carbon Nanoparticles for Biomedical Applications

Sergei Cherevko¹, Arina Efimova¹, Irina Arefina¹, Dmitrii Scherbinin¹, Vadim Rybin¹, Anna Vedernikova¹, Alexander Mitroshin^{1,2}, Elena Ushakova¹

(1) *University ITMO, Kronverksky pr., 49, 197101 St. Petersburg, Russia*

(2) *Branch of Petersburg Nuclear Physics Institute Named by B.P. Konstantinov of National Research Centre “Kurchatov Institute” – Institute of Macromolecular Compounds, Bolshoy pr. V.O., 31, St. Petersburg 199004, Russia*

Contact: S.A. Cherevko (s.cherevko@itmo.ru)

Abstract. This comprehensive study investigates the photothermal conversion efficiency of biocompatible carbon nanoparticles (C-dots) with optical transitions in the red spectral region for potential cancer therapy applications. Three types of C-dots were synthesized using different precursors: glutathione-based (C-dots-Glu), urea-based (C-dots-Urea), and formamide-based (C-dots-FA). Systematic evaluation under laser irradiation at 450, 520, 638 and 1020 nm revealed that C-dots-FA exhibited superior heating performance and photostability across all wavelengths. The thermal conversion efficiency for C-dots-FA (300 µg/mL) reached 18.4% at 638 nm and 7.9% at 1020 nm with an incident power density of 0.6 W/cm². Concentration-dependent studies demonstrated temperature increases up to 48°C within 20 minutes of irradiation. Notably, C-dots-Glu showed significant photodegradation with spectral changes indicating structural modifications, while C-dots-FA maintained excellent stability. All synthesized nanoparticles exhibited negligible photoluminescence when excited at wavelengths longer than their emission, confirming dominant non-radiative relaxation pathways. These findings highlight C-dots-FA as promising, stable, and efficient photothermal agents for in vivo biomedical applications.

The work was supported by the Russian Science Foundation, grant No. 22-13-00294.

ORCID: S.C. 0000-0002-9466-4558, I.A. 0000-0003-1280-042X, D.S. 0000-0003-2212-1252, V.R. 0000-0002-4229-7901, A.V. 0000-0003-1467-9512, A.M. 0000-0002-4705-778X, E.U. 0000-0001-6841-6975

Low Power Density Actuation of Near-infrared Light-Driven AgBiS₂/mSiO₂ Nanomotors

Dušan K. Božanić¹, Danijela Danilović¹, Jelena Pajović², Biljana Ristić³, Anamarija Abu el Rub¹, Vladimir Djoković¹, Anja Boisen⁴, Tijana Mišeljić⁴

(1) Vinča Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

(2) Faculty of Physics, University of Belgrade, Belgrade, Serbia

(3) Institute of Medical Research – National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

(4) Department of Health Technology, Technical University of Denmark, Lyngby, Denmark

Contact: D.K. Božanić (bozanic@vinca.rs)

Abstract. Photothermal nanomotors are hybrid nanosystems that convert incident radiation into motion. These systems possess the capability to perform tasks on small-scale objects in their vicinity in a controllable manner by manipulating the intensity and duration of the incident radiation. In the biomedical field, near-infrared (NIR) light within the wavelength range of 650 nm to 1350 nm is commonly utilized to generate propulsion due to its extensive tissue penetration depth and low phototoxicity. Several hybrid nanosystems have been proposed [1, 2] as light-driven nanomotors capable of achieving velocities exceeding 20 $\mu\text{m/s}$ under NIR actuation. However, reported NIR light-driven nanomotors typically operate under power densities higher than $\sim 2 \text{ W/cm}^2$, which is well above the safety standard for biomedical application ($\sim 0.3 \text{ W/cm}^2$ at 808 nm). In this contribution, we report on fabrication, characterization, and mobility analyses under 808 nm NIR light excitation of hybrid nanosystems composed of silver bismuth sulfide (AgBiS₂) and mesoporous silica (mSiO₂). It will be shown that efficient actuation of the hybrid nanosystems can be achieved by 808 nm irradiation of power density lower than 0.6 W/cm^2 . In addition, the influence of the photothermal actuation on the internalization of AgBiS₂/mSiO₂ nanoparticles in A375 melanoma cells will be briefly discussed.

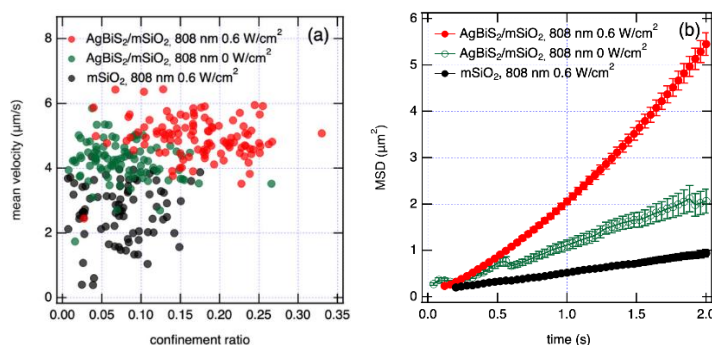


Figure 1. Mobility analyses of AgBiS₂/mSiO₂ nanomotors under 808 nm excitation: (a) classification of particle tracks respective to mean velocity and confinement ratio; (b) mean square displacement of nanomotors.

REFERENCES

- [1] T. Maric et al., *Adv. Health. Mat.* **12** (2023), 2203018
 [2] D. Danilovic et al., *Nano Res.* **18** (2025), 94907505

ORCID: D.B. 000-0001-8246-9635, D.D. 0000-0001-8402-1850, J.P. 0000-0002-3644-0118, B.R. 0000-0002-7255-6556, A.A. 0000-0001-9164-3965, V.Dj. 0000-0001-8237-1101, T.M. 0000-0002-6847-251X

Progress report on wide bandgap oxide semiconductor device modelling

Aleksandar Atić^{1,2}, Novak Stanojević^{3,4}, Nikola Vuković^{2,3}, Milan Ignjatović³, Nikola Basta³, Aleksandar Milićević¹, Aleksandar Demić⁵, Dragan Indjin⁵, Jelena Radovanović^{2,3}

- (1) *University of Belgrade, Vinča Institute of Nuclear Sciences, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*
 (2) *Centre for Light-Based Research and Technologies COHERENCE, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*
 (3) *University of Belgrade, School of Electrical Engineering, Bulevar kralja Aleksandra 73, 11120 Belgrade, Serbia*
 (4) *Vlatacom Institute of High Technologies, Bulevar Milutina Milankovica 5, 11070 Belgrade, Serbia*
 (5) *University of Leeds, School of Electronic and Electrical Engineering, Woodhouse Lane LS2 9JT, Leeds, United Kingdom*

Contact: A. Atić (atic@vin.bg.ac.rs)

Abstract Wide-bandgap semiconductor materials have emerged as key candidates for electronic and optoelectronic devices operating under high power, high frequency, and harsh environmental conditions [1,2]. In this progress report, we present our recent numerical investigations of band structure and transport in wide-bandgap semiconductor devices, with a particular focus on ZnO and Ga₂O₃ material systems [3-5]. Depolarisation shift is included in the optical absorption coefficient calculations. The presented results summarise current modelling capabilities and outline future directions to improve predictive accuracy, thereby supporting the design and optimisation of wide-bandgap semiconductor devices.

REFERENCES

- [1] Ü. Özgür et al., *J. Appl. Phys.* 98 (2005), 041301.
 [2] S. J. Pearton et al., *Appl. Phys. Rev.* 5 (2018), 011301.
 [3] A. Atić, Modeling of quantum nanostructures based on wide bandgap oxide semiconductors, PhD thesis, University of Belgrade School of Electrical Engineering, Belgrade (2025).
 [4] A. Atić et al., *Materials* 17 (2024), 927.
 [5] N. Stanojević et al., *Proc. IcETRAN conf.* (2024), 1–4.

Acknowledgements. This work was financially supported by the Science Fund of the Republic of Serbia, Grant 10504, "Ultra-short pulsations from TERAhertz quantum cascade laser using passive mode-LOCKing with graphene saturable absorber" - TERALOCK, Ministry of Science, Technological Development and Innovation of the Republic of Serbia under contract number: 451-03-137/2025-03/200103, and grant number: 451-03-136/2025-03/200017, COST Action CA21159 PhoBioS, and Vlatacom Institute of High Technologies under project 178.

ORCID: AA: 0000-0001-8436-436X, NS: 0009-0007-5122-2219, NV: 0000-0002-4941-2546, MI: 0000-0001-6066-8764, NB: 0000-0001-6141-7414, AM: 0000-0003-4615-8789, AD: 0000-0003-1335-6156, DI: 0000-0002-9121-9846, JR: 0000-0003-3031-7802

Determination of transport characteristics of high-temperature THz quantum cascade lasers: numerical simulations and machine learning

Nikola Vuković^{1,2}, Aleksandar Milićević³, Mihailo Stojković¹, Aleksandar Demić⁴, Dušan Topalović³, Novak Stanojević^{1,5}, Milan Ignjatović¹, Aleksandar Atić^{1,2,3}, Dragan Indjin⁴, Jelena Radovanović^{1,2}

(1) *University of Belgrade, School of Electrical Engineering, Bulevar kralja Aleksandra 73, 11120 Belgrade, Serbia*

(2) *Centre for Light-Based Research and Technologies COHERENCE, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*

(3) *University of Belgrade, Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*

(4) *University of Leeds, School of Electronic and Electrical Engineering, Woodhouse Lane LS2 9JT, Leeds, United Kingdom*

(5) *Vlatacom Institute of High Technologies, Bulevar Milutina Milankovica 5, 11070 Belgrade, Serbia*

Contact: N. Vuković (nvukovic@etf.bg.ac.rs)

Abstract. We present our recent numerical study, in which the transport simulations are performed using the density matrix model presented in [1]. These results served as a basis for applying different machine learning models to determine the material gain, emission frequency, and current density of a two-well THz quantum cascade laser (QCL) designed for high-temperature operation [2]. In particular, we examine Random Forest (RF) [3], Extreme Gradient Boosting (XGBoost) [4], and Artificial Neural Network (ANN) [5]. RF reduces the variance through ensemble averaging, XGBoost improves predictive performance through gradient-boosted regularization, while ANN architectures employ neural representation learning to capture complex nonlinear relationships. The models were trained by varying the layer widths and external electric bias as the input variables, enabling the prediction of the desired outputs. Combining numerical simulations with machine learning models enables rapid and accurate prediction of key device characteristics, bridging detailed physics-based modelling with efficient data-driven approaches.

REFERENCES

- [1] A. Demić et al., *IEEE Transactions on Terahertz Sci. Technol.* **7** (2017), 368–377.
- [2] A. Khalatpour et al., *Appl. Phys. Lett.* **122** (2023), 161101.
- [3] J. Wekalao et al., *Mater. Sci. Semicond. Process.* **201** (2026), 110064.
- [4] A. Milićević et al., *Thermal Science and Engineering Progress* **57** (2025), 103151.
- [5] D. B. Topalović et al., *Atmos. Environ.* **213** (2019), 640–658.

Acknowledgements. This work was financially supported by the Science Fund of the Republic of Serbia, Grant 10504, "Ultra-short pulsations from TERAhertz quantum cascade laser using passive mode-LOCKing with graphene saturable absorber" - TERALOCK, Ministry of Science, Technological Development and Innovation of the Republic of Serbia under contract numbers 451-03-137/2025-03/200103 and 451-03-136/2025-03/200017, COST Action CA21159 PhoBioS, and Vlatacom Institute of High Technologies under project 178.

ORCID: NV: 0000-0002-4941-2546, AM: 0000-0003-4615-8789, AD: 0000-0003-1335-6156, DT: 0000-0001-5976-963X, NS: 0009-0007-5122-2219, MI: 0000-0001-6066-8764, AA: 0000-0001-8436-436X, DI: 0000-0002-9121-9846, JR: 0000-0003-3031-7802

A novel Ag-Bi-S-I chalco-halide nanomaterial for photovoltaic applications

Danijela Danilović¹, Radovan Dojčilović¹, Dušan K. Božanić¹, and Aleksandar R. Milosavljević²

(1) *Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, P.O. Box 522, 11001 Belgrade, Serbia*

(2) *Synchrotron SOLEIL, L'Orme des Merisiers, 91190 Saint-Aubin, France*

Contact: D. Danilović (danijelad@vin.bg.ac.rs)

Abstract. Perovskite-like lead-free semiconductors are an emerging class of materials, primarily investigated for photovoltaic (PV) applications, as lead-based perovskites, despite their high efficiencies, suffer from toxicity and instability when exposed to oxygen and moisture. Among these materials, multi-anion structures known as chalco-halides (CH) are particularly promising due to optimal band gap values (~1.6 eV) and defect-tolerant structure, fundamental parameters for efficient light energy harvesting. Chalco-halide materials can be classified into several groups based on the type of metal cation: transition-metal CH, heavy pnictogen CH, mixed-metal CH, and organic-inorganic CH [1]. While many of these materials have been synthesized and tested in PV devices, others remain theoretically predicted.

Here, we report the fabrication of Ag-Bi-S-I chalco-halide nanoparticles via a novel synthesis approach. Furthermore, synchrotron radiation X-ray aerosol photoelectron spectroscopy (XASP) was employed to investigate the valence and core level electronic structure. The results are compared with the results of the electronic structure of chalcogenide AgBiS₂ and a previously reported halide Ag-Bi-I system [2].

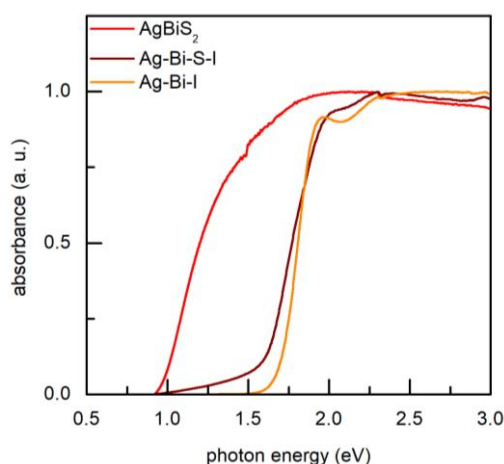


Figure 1. Absorption spectra of AgBiI, AgBiS₂, and Ag-Bi-S-I.

REFERENCES

- [1] S. Shymal, *ACS Energy Lett.* 8 (2023) 3902–3926
- [2] D. Danilović, *J. Phys. Chem. C* **124** (2021), 23930

ORCID: D.D. 0000-0001-8402-1850, R.D. 0000-0002-3478-8268, D.B. 000-0001-8246-9635, A.M. 0000-0003-3541-8872

Dynamics of THz quantum cascade lasers under external optical feedback

Milan Ignjatović¹, Novak Stanojević^{1,2}, Nikola Vuković^{1,3}, Aleksandar Milićević⁴,
Aleksandar Atić^{3,4}, Nikola Basta¹, Jelena Radovanović^{1,3}

(1) *University of Belgrade, School of Electrical Engineering, Bulevar kralja Aleksandra 73, 11120 Belgrade, Serbia*

(2) *Vlatacom Institute of High Technologies, Bulevar Milutina Milankovica 5, 11070 Belgrade, Serbia*

(3) *Centre for Light-Based Research and Technologies COHERENCE, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*

(4) *University of Belgrade, Vinča Institute of Nuclear Sciences, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*

Contact: M. Ignjatović (ignjatovic@etf.bg.ac.rs)

Abstract. The investigation of quantum cascade laser (QCL) dynamics under external optical feedback is crucial for the development of more precise QCL-based sensing and communication devices. In this theoretical contribution, we present our recent numerical results of THz frequency exemplary QCL designs [1] in which we observe different dynamical regimes arising in an external optical feedback configuration [2]. In particular, we identify transitions from single to multimode operation, appearance of frequency combs, and mixed states depending on the length of the external cavity. The parameters used in the dynamics simulations are extracted from carrier transport simulations modelled by a density matrix approach presented in [3], which uses the first neighbour and tight binding approximations, together with the infinite period QCL consideration. The relevant scattering mechanisms are described as perturbations with Fermi's golden rule, using the wavefunctions and material parameters as inputs. For modelling of the laser dynamics under external optical feedback, two approaches based on Maxwell-Bloch equations are used: (i) effective semiconductor Maxwell-Bloch equations [4] with current-dependent input parameters and (ii) standard Maxwell-Bloch equations in the rotating wave approximation (RWA) and the slowly varying envelope approximation (SVEA).

REFERENCES

- [1] R. Köhler et al., *Nature* **417**(2002), 156–159.
- [2] A. Rakić, et al., *Appl. Phys. Rev.* **6** (2019), 021320.
- [3] A. Demić et al., *IEEE Transactions on Terahertz Sci. Technol.* **7** (2017), 368–377.
- [4] C. Silvestri et al., *Optics Express* **28** (2020), 23846–23861.

Acknowledgements. This work was financially supported by the Science Fund of the Republic of Serbia, Grant 10504, "Ultra-short pulsations from TERAhertz quantum cascade laser using passive mode-LOCKing with graphene saturable absorber" - TERALOCK, Ministry of Science, Technological Development and Innovation of the Republic of Serbia under contract number: 451-03-137/2025-03/200103, COST Action CA21159 PhoBioS, and Vlatacom Institute of High Technologies under project 178.

ORCID: MI: 0000-0001-6066-8764, NS: 0009-0007-5122-2219, NV: 0000-0002-4941-2546, AM: 0000-0003-4615-8789, AA: 0000-0001-8436-436X, NB: 0000-0001-6141-7414, JR: 0000-0003-3031-7802

Butterfly-like microfluidic chip integrating a 3D-printed biomimetic scaffold for multimodal in vitro optical analysis of neuronal system

F. Torrini^{1,2}, C. Dallari^{1,2} and I. Masi¹, Maria Giovanna Cataldi³, Anna Letizia Allegra Mascaro^{5,2}, Ana Jakovljevic⁴, M. Rojas Rodríguez², Tanja Pajic⁴, M. Catarzi², Francesco Saverio Pavone^{1,2,6}, M. Calamai², S. Nocentini^{2,7}, Brana Jelenkovic⁸, Pavle Andjus⁴, C. Credi^{1,2}

(1) National Institute of Optics, National Research Council (INO-CNR), Via Nello Carrara 1, 50019 Sesto Fiorentino, Italy

(2) European Laboratory for Non-linear Spectroscopy (LENS), Via Nello Carrara 1, 50019 Sesto Fiorentino, Italy

(3) Department of Neuroscience, Psychology, Drug Research and Child Health - NEUROFARBA - Pharmacology and Toxicology Section, University of Florence, Florence, Italy.

(4) Institute of Physiology and Biochemistry "Ivan Djaja", Faculty of Biology, University of Belgrade, Studentski trg 3, 11001, Belgrade, Serbia

(5) Neuroscience Institute, National Research Council, Pisa, Italy

(6) Department of Physics, University of Florence, Sesto Fiorentino 50019, Italy

(7) National Institute of Metrology (INRiM), Strada delle Cacce 91, 10135, Turin, Italy

(8) Institute of Physics Belgrade, University of Belgrade, National Institute of the Republic of Serbia, Pregrevica 118, 11080 Belgrade, Serbia

Contact: F. Torrini (francesca.torrini@lens.unifi.it)

Abstract. Lab-on-a-chip (LoC) devices combined with advanced additive manufacturing technologies hold significant potential as versatile systems for advancing the study of biophysical and biochemical processes, including cellular dynamics. These technologies are currently supporting ongoing research efforts in the fields of bioengineering and material science, which are driving the development of sustainable, bio-derived and human-specific in vitro approaches aimed at modeling physiopathological processes to study diagnostic and therapeutic approaches. In this context, we developed a butterfly-like microfluidic chip with an open chamber configuration for culturing cells that provides direct access for biophotonic investigation. Four external reservoirs enable passive medium exchange to support cell growth and proliferation, while microchannels are used to apply controlled stimuli. The chip prototype was fabricated via stereolithography to ensure high-resolution feature design, followed by a PDMS molding replication process to ensure scalability and reproducibility. A 3D biomimetic scaffold, fabricated by digital light processing (DLP) [1], was incorporated into the culture chamber to provide a microenvironment that is both structurally and mechanically tunable, and which mimics natural extracellular matrices (EMC) through cell-cell and cell-EMC interactions that closely resemble those in native tissues. This hybrid platform is designed to enable real-time, multimodal optical analysis of cellular processes, with a particular focus on neuronal applications. As a proof of principle, neuroblastoma cells (SH-SY5Y) were successfully differentiated and analyzed on-chip to exhibit neuron-like phenotypes, as highlighted by morphological analysis (such as neurite extension) neuronal biomarker expression, and Ca²⁺ dynamics [2]. The chip was also used to investigate SH-SY5Y cells transfected with amyloid precursor protein (APP) fused to monomeric fluorescent proteins at both termini (mChAPPmGFP) [3], which enabled the exploration of disease-relevant cellular states under controlled stimulation. Overall, this microfluidic-3D scaffold platform represents a versatile and scalable approach for studying neuronal function in dynamic and three-dimensional environments. It has potential applications in disease modeling, drug screening, and translational neuroscience. **The modular architecture of the system further enables future extensions toward more complex culture configurations, including co-culture approaches and patient-derived cells, contributing to the development of physiologically relevant neural models at a time of growing clinical relevance.**

[1] Y-W. Moon, et al., *Materials Today Bio* 32 (2025), 101786.

[2] R. B. Kartal et al., *ACS Omega* 9 (2024), 14955-14962.

[3] C. Capitini, A. Bigi et al., *iScience* 26 (2023), 106611.

An AI-assisted multimodal diagnostic test for heart failure

Jovana Petrović¹

(1) *Vinča Institute of Nuclear Sciences, National Institute of the RS, University of Belgrade
Mike Petrovića Alasa 12-14, 11351, Belgrade, Serbia*

Contact: J. Petrović (jovanap@vin.bg.ac.rs)

Abstract. Heart failure (HF) – inability of the heart to provide a sufficient amount of blood for normal body function, represents an immense societal burden due to a high mortality rate (50% of patients die within 5 years from diagnosis), global pandemic proportions and high healthcare expenditures. When diagnosed in an early phase, HF can be arrested or even reversed, while a late diagnosis inevitably leads to the fatal outcome. However, 70% of cases are diagnosed only upon a series of tests: ECG, biochemical and echocardiographic, in secondary care [1], leaving many patients not treated timely or at all. Hence, coordinated efforts are underway across medical and engineering communities to establish new tests suitable for primary care and screening. We joined these efforts through the project SensSmart, focused on the development of multimodal sensor technology for timely HF diagnosis.

SensSmart technology relies on non-invasive synchronized measurement of electrical and mechanical processes in the cardiovascular system, including the electrocardiogram, heart sounds and movement, and arterial pulsations. Rooted in earlier investigations [2], our technology leverages modern electrical, mechanical and photonic sensing [3], along with AI-based data processing [4], to provide an HF diagnostic test suitable for primary care. We stress the enabling role of deep learning, noting that its capability to simultaneously process numerous features of different physiological signals and their interdependences surpasses that of humans. The algorithm was trained on data from the SensSmart clinical study conducted from Oct 2023 to Sep 2025 at two centres of the University Clinical Centre of Serbia. Based on the preliminary analysis, the system performs binary HF classification with a sensitivity of 90% and an F1-score of 87%, while demonstrating a clear trend of performance improvement with the addition of new modalities.

During the talk, I will provide details of the sensing system, classification algorithm and clinical training set and outline future system upgrades.

The research is supported by the Science Fund of the Republic of Serbia, Grant. No. 7754338, Multi-SENSor System and ARTificial intelligence in service of heart failure diagnosis – SensSmart.

REFERENCES

- [1] T. A. McDonagh et al., “2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure,” *Eur. Heart J.*, vol. 42, pp. 3599–3726, 2021.
- [2] A. M. Weissler, W. S. Harris, C. D. Schoenfeld, *Circulation* **37** (1968) 149.
- [3] A. Lazović, V. Atanasoski et al. J. Synchronous post-exercise electrocardiogram, phonocardiogram, photoplethysmograms and seismocardiogram. *Sci. Data* **12** (2025) 1452.
- [4] M. Tiosavljević, J. Petrović, P. Tadić, Heart Failure Detection Using Photoplethysmography and Deep Learning, 12th International Conference on Electrical, Electronic and Computing Engineering (IcETRAN) (2025), <https://doi.org/10.1109/IcETRAN66854.2025.11114317>

ORCID: 0000-0002-1002-241X

Sound-Driven Control of Quantum Light for Robust Time-Bin Photonic Qubits

Sanja Djurdjić Mijin^{1,2}, Snežana Lazić Knežević^{1,3,4}

(1) *Departamento de Física de Materiales, Facultad de Ciencias, Universidad Autónoma de Madrid (UAM), 28049 Madrid, Spain*

(2) *Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*

(3) *Instituto Universitario de Ciencia de Materiales “Nicolas Cabrera” (INC, UAM, 28049 Madrid, Spain*

(4) *Condensed Matter Physics Center (IFIMAC), UAM, 28049 Madrid, Spain*

Contact: Sanja Djurdjić Mijin (sanja.djurdjic@uam.es)

Abstract. Reliable quantum communication requires photonic qubits that remain robust during transmission through existing fibre networks, where environmental fluctuations and material imperfections can degrade fragile quantum states. While polarization encoding is widely implemented due to its conceptual simplicity and ease of generation and detection, it is inherently vulnerable to polarization mode dispersion, birefringence, and thermal or mechanical perturbations in optical fibres. These effects lead to decoherence and state mixing, which severely limit transmission fidelity over long distances and reduce the scalability of polarization-based quantum communication systems. As quantum networks move toward real-world implementation using installed telecommunication infrastructure, these limitations motivate the exploration of alternative photonic degrees of freedom that are less sensitive to channel-induced noise. Time-bin encoding has emerged as a particularly attractive solution because it relies on photon arrival times rather than polarization orientation, making it intrinsically resilient to polarization fluctuations and compatible with long-haul fibre links. However, practical implementation of time-bin qubits places stringent requirements on deterministic photon generation, high temporal precision, and fast modulation capabilities, all of which demand advanced control over the emission dynamics of single-photon sources.

Here we demonstrate acoustically driven control of quantum light emission as a pathway toward time-bin encoded single-photon sources. Our platform consists of GaN/InGa_N core-shell nanowires hosting quantum-dot-like localization centres, mechanically dispersed onto piezoelectric LiNbO₃ substrates with radio-frequency surface acoustic wave (SAW) delay lines. These localization centres exhibit narrow, strongly linearly polarized excitonic and biexcitonic transitions with clear photon antibunching, confirming their single-photon character. When driven by SAWs at ~330 MHz, the emitters experience periodic strain and piezoelectric fields that induce dynamic spectral modulation of ~2 meV. Phase-locked stroboscopic measurements reveal emission oscillations synchronized to the SAW cycle. Unlike many SAW-controlled systems where sequential carrier capture dominates, our observations indicate field-assisted simultaneous injection of electrons and holes from the surrounding InGa_N region. By combining SAW-induced tuning with spectral filtering, we achieve controlled photon emission at selected phases of the acoustic cycle, enabling programmable photon arrival times.

This acoustically mediated control scheme provides a compact and scalable route toward time-bin photonic qubits compatible with fibre-based quantum networks. Additionally, the presence of biexcitonic emission highlights the potential of III-nitride nanowire emitters for elevated-temperature entangled photon generation.

ORCID: 0000-0002-4597-8219

Light-Driven Riboflavin loaded Au/TiO₂ micromotors as a Promising Strategy for Targeted Melanoma Therapy

Biljana Ristić¹, Danijela Danilović², Radoš Stefanović¹, Jelena Pajović³, Tamara Đukić⁴, Vladimir Djoković², Vesna Ilić¹, Radovan Dojčilović²

(1) Institute for Medical Research - National Institute of the Republic of Serbia, University of Belgrade, Dr. Subotića 4, PO Box 39, 11129 Belgrade, Serbia

(2) Center of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, PO Box 522, 11001 Belgrade, Serbia

(3) University of Belgrade, Faculty of Physics, Studentski trg 12, Belgrade 11001, Serbia

(4) Innovation Center of the Faculty of Technology and Metallurgy, Karnegijeva 4, 11120, Belgrade, Serbia

Contact: B.Ristić (biljana.ristic@imi.bg.ac.rs)

Abstract. Light-driven metal-oxide micromotors have emerged as promising theranostic tools for efficient tumor penetration and intracellular drug delivery, enabling more precise targeting and enhanced treatment of malignant cells [1,2]. Titanium oxide (TiO₂) micromotors can overcome tumor microenvironmental barriers under light irradiation and propel themselves using tumor-derived H₂O₂ [3]. This self-propulsion enhances cellular uptake and therapeutic efficacy, although the exact mechanisms underlying their antitumor activity remain incompletely understood [4]. In this study, we characterized the physicochemical properties and investigated the biological effects of newly developed riboflavin (vitamin B₂)-loaded gold–titanium dioxide (Au/TiO₂-RbF) micromotors in human A375 melanoma cells in vitro. Structural analysis by SEM revealed that the Au/TiO₂ particles were spherical, uniform, and well dispersed, with an average diameter of approximately 1 μm, consistent with DLS measurements. Elemental mapping using HRTEM/EDS confirmed a homogeneous distribution of Au, Ti, and O throughout the particles. UV–vis spectroscopy of the Au/TiO₂ micromotors showed strong absorption in the UV region (200–400 nm), characteristic of TiO₂, along with an additional peak at 550 nm corresponding to Au. Photoluminescence excitation analysis demonstrated stable and intense UV fluorescence with a maximum emission at 360 nm upon 280 nm excitation, accompanied by visible emission originating from RbF in the 500–600 nm range. Importantly, riboflavin acts as an efficient photosensitizer, and its activation under UVA irradiation leads to enhanced reactive oxygen species (ROS) generation. Using EPR spectroscopy, we demonstrated significantly increased singlet oxygen production from Au/TiO₂-RbF micromotors upon UVA exposure, confirming the photoactivated ROS-generating capability of the system. To evaluate the biological effects, MTT assays revealed no significant cytotoxicity of the micromotors (5–20 μg/mL) in non-irradiated A375 human melanoma cells after 24 h of treatment. In contrast, UVA irradiation for 2 h triggered dose-dependent cytotoxicity in micromotor-treated cells. Phase-contrast microscopy further revealed morphological changes consistent with apoptotic cell death. Collectively, these results demonstrate that RbF-loaded Au/TiO₂ micromotors induce UVA-triggered, ROS-mediated apoptosis in A375 melanoma cells while exhibiting minimal toxicity in the absence of irradiation. Taken together, our findings highlight the potential of Au/TiO₂-RbF micromotors as a safe and effective light-activated platform for targeted anti-melanoma therapy.

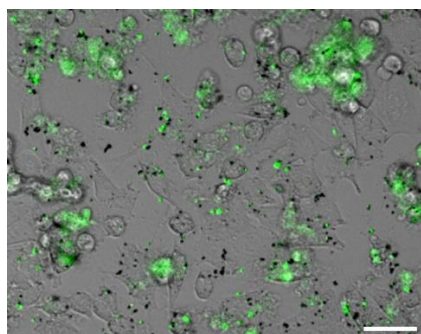


Figure 1. UVA treated A375 melanoma cells incubated with Au/TiO₂-RbF micromotors. Scale bar is 50 microns.

[1] X. Zeng, et al. *Nanoscale*. **15** (2023), 18550-70.

[2] M. Wan, et al. *Angewandte Chemie International Edition*. **59** (2020), 14458-66.

[3] J. Ren, et al. *Applied Materials Today*. **27** (2022), 101445.

[4] H. Wang, et al. *Small*. **20** (2023), 2306208.

ORCID: B.R. 0000-0002-7255-6556, D.D. 0000-0001-8402-1850, R.S. 0009-0003-4696-2053, J.P. 0000-0002-3644-0118, T.Đ. 0000-0001-5897-6354, V.Đ. 0000-0001-8237-1101, V.I. 0000-0003-1119-1343, R.D. 0000-0002-3478-8268

Erythrocyte Light Side Scattering as a Label-Free Flow Cytometric Marker of Type 2 Diabetes Mellitus

Mihajlo D. Radmilović¹, Vesna Lj. Ilić², Dušan D. Vučetić^{3,4}, Radoš Stefanović², Biljana Ristić², Ana Petakov⁵, Katarina Lalić^{5,6}, Aleksandar J. Krmpot¹, Ivana T. Drvenica²

(1) Institute of Physics Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

(2) Institute for Medical Research, Bulevar Oslobođenja 18, 11000 Belgrade, Serbia

(3) Institute for Transfusiology and Haemobiology, Military Medical Academy, Belgrade, Serbi

(4) Faculty of Medicine, Military Medical Academy, University of Defence, Belgrade, Serbia

(5) Clinic for Endocrinology, Diabetes and Metabolic Diseases, University Clinical Center of Serbia, Dr. Subotića 13, Belgrade 11000, Serbia

(6) Faculty of Medicine, University of Belgrade, Dr. Subotića 8, Belgrade 11000, Serbia

Contact: I. Drvenica (ivana.drvenica@imi.bg.ac.rs)

Abstract. Flow cytometry enables high-throughput single-cell analysis via light scattering, yet its use in erythrocyte characterization remains limited [1]. Light-scattering descriptors can enable the detection of morphological and deformability changes associated with conditions such as renal failure, sepsis, systemic inflammation, and diabetes mellitus (DM) [2,3]. Our previous work with erythrocytes from healthy donors showed that side scatter (SSC) provides a stable optical indicator of erythrocyte shape and is more robust to preanalytical variability than forward scatter (FSC) [1]. However, SSC distributions often exhibit asymmetry and overlapping subpopulations that cannot be adequately described by simple parametric models, particularly in the presence of inter-patient variability.

In the present work, SSC of erythrocytes from patients with type 2 DM (n=8) and age-matched healthy controls (n=9) were measured using a BD FACSCalibur flow cytometer (Becton, Dickinson, USA) following incubation in a 93 mM sodium phosphate buffer [1], while deformability was determined by RheoScan-D300 ektacytometer (RheoMeditech Inc., Korea) [3]. The SSC intensity histograms were fitted using kernel density estimation (KDE) method to produce a smooth, nonparametric estimate of their underlying distribution (Figure 1). Considering that SSC reflects erythrocyte internal structure and shape-related heterogeneity, along with the demonstrated reduced deformability and the presence of subpopulations of erythrocytes in type 2 DM patients, our findings indicate that KDE-based SSC analysis proved to be particularly valuable for resolving overlapping subpopulations and for robustly comparing erythrocyte SSC distributions across type 2 DM samples.

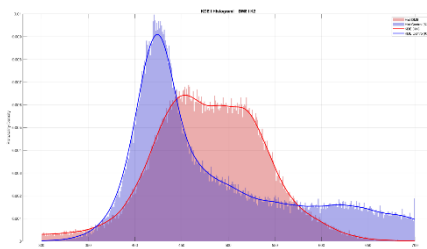


Figure 1. Representative KDE of the SSC histogram of type II DM (red) and healthy erythrocytes (blue)

REFERENCES

- [1] I. Drvenica, S. Mojsilović, et al., *Eur. Biophys J.* 50(6) (2021), 829-846.
- [2] C. Nobre, J. Silva, *Cytom B: Clin. Cytom.* 94(6) (2018), 910-917.
- [3] M.D. Radmilović, V.L. Ilić et.al., *Spectrochim. Acta A Mol. Biomol. Spectrosc.* 327 (2025), 125

ORCID: I.D. 0000-0001-6578-2304, V.Lj. 0000-0003-1119-1343, D.V. 0000-0002-7435-5520, R.S. 0009-0003-4696-2053, B.R. 0000-0002-7255-6556, A.P. 0009-0000-8132-627X, K.L. 0000-0002-8070-1899, A.K. 0000-0003-2751-7395, I.D. 0000-0003-4985-1642

Photonics and Microbiology

Peter Galajda¹

(1) *Institute of Biophysics, HUN-REN Biological Research Centre, Temesvari krt. 62., H-6726 Szeged, Hungary*

Contact: Peter Galajda (galajda.peter@brc.hu)

Abstract. Bacteria are the simplest life forms on Earth. Yet they demonstrate complex structures, biological function, and behavior that are far from being fully understood. For example, the ability of bacteria to communicate with each other results in the emergence of complex spatial patterns and multispecies communities. Light based techniques are being used since the nascence of microbiology (e.g. optical microscopy, optical densitometry, etc.). Recently, laser-based photonics contribute greatly to microbiology research with new techniques that open unprecedented experimental possibilities. In this talk I present several examples to how (bio)photonics-based methods help us understand the evolution, ecology and cellular biology of microbes.

Nonlinear Imaging and Laser Nano Surgery of Hyphae to Enable Electrophysiological Measurements

Tanja Pajić¹, Katarina Stevanović¹, Marta Bukumira¹, Nataša Todorović², Svetlana Savić Šević³, Miroslav Živić¹, Mihailo Rabasović³ and Aleksandar Krmpot³

(1) Faculty of Biology, University of Belgrade, Serbia

(2) Institute for Biological Research “Siniša Stanković”, University of Belgrade, Serbia

(3) Institute of Physics Belgrade, University of Belgrade, Serbia

Contact: A. Krmpot (krmpot@ipb.ac.rs)

Abstract. Electrophysiology studies of ion channels, in live filamentous fungi by patch clamp method are not possible due to presence of rigid chitinous cell wall that prevents patch clamp pipette to access the plasma membrane. We present laser nano-surgery of the fungal cell wall that enables patch clamp electrophysiology studies. Similar approaches as one-time reports utilizing nanosecond laser pulses long time ago were not pursued further (Roberts 1997, Véry 1998). Here, we demonstrate reproducible method using femtosecond lasers accompanied by two-photon excitation fluorescence (TPEF) imaging of hyphae (Pajić 2024).

A wild-type strain of filamentous fungus *Phycomyces blakesleeanus* (Burgeff) [NRRL 1555(-)] were grown on glass coverslips with hand-etched grid, coated with a thin layer of 50% collagen type I as an immobilizer. Home built nonlinear laser scanning microscope (Pajić 2022) utilizing Ti:Sa tunable fs laser was used for TPEF imaging of hyphae and the cell surgery. The latter is enabled with the custom made add-on in software. The dwell time (1s) and the laser power (4-15mW) were set with fixed repetition rate (76MHz), pulse duration (160fs) and laser wavelength (730nm). Coverslip with hyphae is transferred to another microscope setup for patch clamp, consisting of micromanipulators and precise electronics for pA current measurements. Obtained current recordings provide valuable information on fungal cell membrane ionic channels. Based on the obtained results, a new integrated instrument is developed, combining nonlinear microscope and patch clamp instrumentation. The time measurement time is shortened significantly, as well as the stress imposed to hyphae.

Funding: project BioPhysFUN, program GREEN, Science Fund of the Republic of Serbia; Ministry of Science and Technological Development and Inventions of the Republic of Serbia.

REFERENCES

- [1] Roberts, Stephen K. et al, *The New Phytologist* **137** (1997), 579–85.
- [2] Véry AA, Davies JM, *Applied and Environmental Microbiology*, **64** (1998) 1569-72.
- [3] Pajić Tanja, et al, *Microsystems & Nanoengineering* **10** (2024), 47.
- [4] Pajić Tanja, et al, *Scientific Reports* **12** (2022), 18760

ORCID: T.P. 0000-0003-3794-7655, K.S. 0000-0001-9733-2367, M.B. 0000-0003-2313-7344, N.T. 0000-0003-2626-0794, S.S.Š 0000-0002-6406-0745, M. Ž. 0000-0002-0314-5032, M. R. 0000-0002-9235-4388, A.K. 0000-0003-2751-7395

Searching for dark matter with optical sensors

Szymon Pustelny^{1,2}

(1) *Institute of Physics, Jagiellonian University in Kraków, Łojasiewicza 11, 30-348, Kraków, Poland*

(2) *Department of Physics, Harvard University, 17 Oxford St., 02138, Cambridge, MA, USA*

Contact: S. Pustelny (pustelny@uj.edu.pl)

Abstract. Dark matter remains one of the most significant unresolved problems in contemporary physics. Although its direct detection has not yet been achieved, a broad consensus regarding its existence is supported by compelling astrophysical and cosmological observations. The limited knowledge of its microscopic properties motivates a wide range of experimental searches exploring diverse theoretical scenarios. One particularly well-motivated class of models involves ultralight dark matter, which may interact with ordinary matter through exotic, non-magnetic, spin-dependent couplings. Owing to their extremely low mass, such particles are expected to behave as coherently oscillating classical fields rather than as individual microscopic objects. This paradigm shift necessitates the development and implementation of novel experimental search strategies. To address this challenge, we have developed and refined optical spin-based sensors designed to detect such interactions [1]. These sensors exhibit strongly suppressed sensitivity to conventional magnetic fields—one of the dominant noise sources in many dark matter searches—while maintaining exceptionally high sensitivity to non-magnetic spin couplings. This combination makes them particularly well suited for precision searches for ultralight dark matter. In this contribution, we present the experimental techniques employed in these searches and review several recent measurements performed using our optical sensor platform [2–4]. We discuss the resulting constraints on ultralight dark matter models, highlighting the achieved sensitivities and excluded regions of parameter space. Finally, we outline future experimental strategies and technological improvements aimed at further extending the reach of spin-based searches for ultralight dark matter.

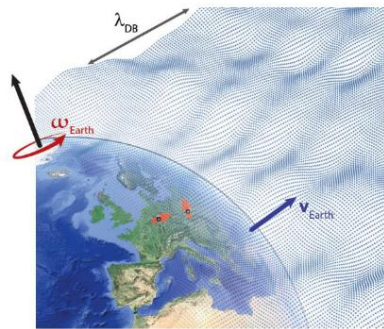


Fig. 1. Schematic diagram illustrating searches for stochastic dark matter. Adapted from Ref. [4]

Acknowledgments: This work was supported by the National Science Centre of Poland within the OPUS grant (grant No. 2019/34/E/ST2/00440). Some of the presented results were obtained within the GNOME collaboration [5].

REFERENCES

- [1] M. Padniuk et al., *Physical Review Research* 6, 013339 (2024).
- [2] S. S. Khamis et al., *Physical Review X* 15, 031048 (2025).
- [3] D. Gavilan-Martin et al., *Nature Communications* 16, 4953 (2025).
- [4] Y. Wang et al., *Nature* (in press).
- [5] <https://budker.uni-mainz.de/gnome/>

ORCID: 0000-0003-3764-1234

Numerical analysis of frequency-modulated optical pumping with integrated hyperfine repumping for high-accuracy magnetometry

Zoran D. Grujić¹, Theo Scholtes², Marija Ćurčić¹

(1) Institute of Physics Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

(2) Leibniz Institute of Photonic Technology, Albert-Einstein-Straße 9, 07745 Jena, Germany

Contact: Z.D. Grujić (zoran.grujic@ipb.ac.rs)

Abstract. Optically pumped magnetometers (OPMs) provide a compelling balance of high sensitivity, compact footprints, and low operational overhead, securing their role across diverse fields including biomagnetism, geophysical surveying, and fundamental physics. This work focuses on accuracy-critical applications, utilizing Free Alignment Precession (FAP) in antirelaxation-coated ¹³³Cs vapor cells. Our approach employs a sequential two-step measurement protocol: initial optical pumping (OP) into an aligned state via linearly polarized light, followed by the observation of the FAP signal using a weak probe beam. Similar method was demonstrated by J. Belfi, et.al. where circularly polarized light was used for OP [1]. This method refines established free-spin precession techniques to enhance long-term stability and absolute accuracy [2].

In this study, we present numerical simulations of optical pumping performed with wide frequency-modulated (FM) light at the D₁ line. In this configuration, a single laser source simultaneously produces Zeeman coherences and performs hyperfine repumping. We demonstrate a significant increase in the produced alignment when hyperfine repumping is employed compared to cases where it is absent. The primary objective of this investigation is to predict the optimal laser power and modulation duty cycle. We complemented our preliminary experimental results with these simulations to gain a deeper understanding of the underlying atomic dynamics. As illustrated in Figure 1, both the alignment oscillation amplitude and the ground-state population redistribution are presented as functions of the Rabi frequency. Our simulation predicts an approximate fourfold increase in signal amplitude; however, experimental measurements show a twofold increase. We will discuss the potential reasons for this discrepancy and explore the implications for future magnetometer design.

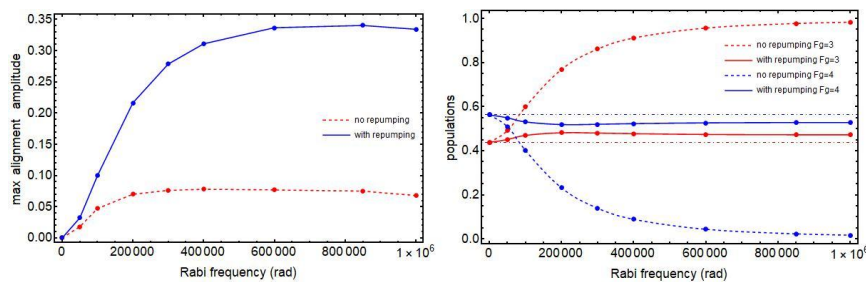


Figure 1. (Left) Amplitude of alignment oscillations at the double Larmor frequency for cases with (blue) and without (red) repumping. (Right) Redistribution of hyperfine ground-state populations with (solid line) and without (dashed line) repumping.

REFERENCES

- [1] J. Belfi, G. Bevilacqua, V. Biancalana, S. Cartaleva, Y. Dancheva, K. Khanbekyan, and L. Moi, *J. Opt. Soc. Am.* **26** (2009), 910-916.
- [2] Z.D. Grujić, P.A. Koss, G. Bison, A. Weis, *Eur. Phys. J. D* **69**, 135, (2015)

ORCID: Z.G. 0000-0003-0802-5782, T.S. 0000-0001-6121-2574, M.Ć. 0000-0001-6920-3461

New surveillance and detection system for military vehicles

Dragan Lukić¹, Časlav Lukić¹

(1) *Institute for physics, Pregrevica 118, 11080 Belgrade, Serbia*

Contact: D. Lukić (lukic@ipb.ac.rs)

Abstract. Big war still rages over part of Europe [1]. Present situation with new treat from drones will be presented, and overview what is now applied on military vehicles. We will present our work on new system for visual and acoustic detection of drones and new concept of visual perception of a situation in hope that it contribute for humane protection. We use Arduino, single-board microcontroller for building our digital device.

REFERENCES

- [1] D. Lukić, *Workshop of Photonics 2016, Book of abstracts* (2016), 37 (abstract).

Holographic and Nonlinear Microscopy for Investigating Glial Cell Morphology

Ana Jakovljević¹, Tanja Pajić¹, Filip Krajinić^{4,5}, Svetlana Savić-Šević⁵, Branka Murić⁵, Francesca Torrini², Caterina Dallari^{2,3}, Caterina Credi^{2,3}, Pavle Andjus¹, Branislav Jelenković⁵

(1) Faculty of Biology, Institute of Physiology and Biochemistry “Jean Gaja”, University of Belgrade, Studentski trg 16, 11158 Belgrade, Serbia

(2) University of Florence; National Institute of Optics, National Research Council (INO-CNR), Sesto Fiorentino, Italy

(3) European Laboratory for Non-Linear Spectroscopy (LENS), Sesto Fiorentino (FI), Italy

(4) University of Belgrade, School of Electrical Engineering, Bulevar kralja Aleksandra 73, 11120 Belgrade, Serbia

(5) Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Zemun, Belgrade, Serbia

Contact: A. Jakovljevic (ana.jakovljevic@bio.bg.ac.rs)

Abstract. Holographic and nonlinear two-photon microscopy provide complementary approaches for imaging biological samples by combining quantitative phase measurements with nonlinear optical contrast, that have access to both physical and structural cellular properties beyond conventional intensity-based microscopy. In this study, these techniques were applied to investigate the morphology of cultured glial cells labeled with gold nanoparticles (Au NPs). Au NPs were conjugated to wheat germ agglutinin (WGA) as a membrane marker and used to label primary rat astrocytes and BV2 murine microglial cell line. Holographic amplitude images provided limited contrast, while phase imaging revealed additional information related to cell thickness and refractive index, indicating potential sensitivity to physiological changes. In BV2 cells, femtosecond two-photon excitation at 1040 and 800 nm produced membrane-associated signal; however, signals observed in negative controls suggest only a contribution from endogenous autofluorescence. These results highlight the potential and feasibility of phase-imaging in holographic microscopy while AuNPs help in membrane non-linear imaging.

Acknowledgment: This work was supported by the Horizon WIDERA 2021-ACCESS-03-01 grant, #101079355 “BioQantSense” and 4242 Science Fund RS, I-PHOQS

ORCID: A.J. 0000-0002-3035-1587; T.P. 0000-0003-3794-7655; F.K. 0009-0008-0284-9426; S.S. 0000-0002-6406-0745; B.M. 0000-0003-3003-1708; F.T. 0000-0003-3846-4145; C.C. 0000-0003-4565-5214; C.D. 0000-0003-1787-0697; P.A. 0000-0002-8468-8513; B.J. 0000-0001-8276-1169

Biomedical application of diamond-based quantum sensing

Arne Wickenbrock¹

(1) *Johannes Gutenberg University Mainz: Mainz, Rheinland-Pfalz, DE*

Contact: A. Wickenbrock (wickenbr@uni-mainz.de)

Abstract. Optically pumped magnetometers are highly sensitive devices at the forefront of international quantum-sensing initiatives. In this talk, I will present our color-center–based sensing projects, with a particular focus on our efforts to detect neuronal action potentials using a diamond endoscope developed within the BMFTR-funded quantum-sensing lighthouse project DIAQNOS.

DIAQNOS—Diamond Quantum Sensing for Neurosurgery—is a collaborative initiative between quantum physicists across Germany and neurosurgeons at the University Clinic Freiburg. Its goal is to translate the impressive performance of quantum sensors in the laboratory into the neurosurgical operating theater, where they could support diagnostics, enhance neuronavigation, and ultimately improve patient outcomes.

BioQuantSense: Management Approaches and Lessons Learned from a WIDERA Twinning Project at the Institute of Physics Belgrade

Giulia Adembri¹, Donata Fornaciari¹, Pasqualina Pipino¹, Caterina Credi¹, Frank Setzpfandt², Christian Helgert², Marina Lekić³, Dušica Vukcevic Stojiljkovic³, Brana Jelenkovic³

(1) *National Institute of Optics of National Research Council, via Nello Carrara 1, Sesto Fiorentino (Florence), Italy*

(2) *Abbe Center of Photonics (ACP) of the Friedrich Schiller University Jena, Fuerstengraben 1, 07743 Jena, Germany*

(3) *Institute of Physics Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*

Contact: G. Adembri (giulia.adembri@cnr.it)

Abstract. The BioQantSense project (Twinning for Excellence of the Serbian Research Center for Quantum Biophotonics) aimed to strengthen the scientific capabilities and organizational maturity of the Photonics Center (PC) at the Institute of Physics Belgrade (IPB). The initiative was structured around three core objectives: (O1) advancing IPB-PC's scientific excellence by fostering the emerging field of quantum biophotonics and enhancing classical biophotonics, including holographic two-photon and single-photon direct laser writing with novel photopolymers and innovative stimuli-responsive materials; (O2) reinforcing management competencies and improving administrative structures at IPB-PC and IPB; and (O3) establishing a dedicated Center for Quantum Biophotonics within IPB.

Alongside its scientific objectives—strengthening IPB's scientific excellence and supporting the Photonics Center in launching new research directions—the project placed significant emphasis on enhancing management competencies, professionalizing administrative procedures, and improving institutional governance.

By targeting management-oriented activities such as project management workshops, administrative process optimization, and capacity-building actions, BioQantSense implemented a comprehensive methodology that addressed operational challenges while enabling significant achievements. These efforts enhanced IPB-PC's capacity to manage externally funded projects and supported the consolidation of international scientific collaboration expected to continue beyond the project's lifetime. Overall, the project's methodological approach was essential for ensuring the long-term sustainability of research excellence and for preparing IPB-PC to successfully lead and coordinate future international initiatives.

Acknowledgement. This work was supported by the Horizon WIDERA 2021-ACCESS-03-01 grant, #101079355 “BioQantSense”.

A

Abu el Rub · 44
Adembri · 61
Allegra Mascaro · 49
Andjus · 49, 59
Antic · 25
Arefina · 43
Arsenović · 19
Atanasijević · 38
Atić · 45, 46, 48

B

Bajić · 33
Bano Otalora · 24
Banović · 38
Baranov · 30
Basta · 45, 48
Bataveljic · 27
Bellas · 28
Bodria · 18
Bogdanov · 30
Boisen · 44
Božanić · 21, 44, 47
Božinović · 20
Bradley · 18
Bugarski · 28, 34
Bukumira · 55

C

Calamai · 49
Cataldi · 49
Catarzi · 49
Cheli · 18
Cherevkvov · 43
Cicchi · 36
Costantini · 18
Credi · 49, 59, 61
Crnjanski · 38
Ćurčić · 15, 19, 57

D

Dallari · 49, 59
Danilović · 44, 47, 52

Demić · 45, 46
Di Meo · 18
Didikoglu · 24
Didukh · 30
Djoković · 21, 44, 52
Djurdjić Mijin · 51
Djurović · 22
Dojčilović · 21, 47, 52
Dramićanin · 33
Drvenica · 53
Đukić · 52
Dupish · 15, 35

E

Efimova · 43

F

Fenizi Caria · 18
Firez · 15
Fornaciari · 61

G

Galajda · 54
Gandolfi · 18
Gillespie · 24
Grudinkin · 30
Grujić · 57
Gvozdić · 38

H

Hadžievski · 31
Harmer · 24
Helgert · 61

I

Ignjatović · 45, 46, 48
Ilić · 52, 53
Indjin · 45, 46
Ivanović · 31

J

Jakovljević · 49, 59
 Jelenković · 15, 19, 32, 49, 59, 61
 Jelić · 26
 Joža · 33

K

Kelemen · 17
 Kiković · 15
 Kovačević · 33
 Krajinić · 15, 19, 59
 Krmpot · 53, 55
 Krstić · 38
 Kügler · 40

L

Lagarto · 36
 Lalić · 53
 Lazić Knežević · 51
 Lekić · 15, 19, 32, 61
 Lukić · 58

M

Maluckov · 28, 31, 34
 Mapelli · 18
 Mašanović · 28
 Masi · 49
 Mazzamuto · 18
 Miletić · 31
 Milićević · 45, 46, 48
 Milivojević · 21
 Milosavljević · 24
 Milosavljević · 47
 Miseljic · 29
 Mišeljić · 44
 Mitrić · 26
 Mitroshin · 43
 Molodcov · 42
 Murić · 59

N

Nocentini · 37, 49
 Nodop · 40
 Novaković · 20

P

Pajić · 19, 49, 55, 59
 Pajović · 21, 44, 52
 Pantelić · 19
 Pavone · 18, 49
 Perego · 18
 Petakov · 53
 Petrović · 20, 28, 31, 34, 50
 Petrović J. · 8
 Pipino · 61
 Pustelny · 56

R

Rabasović · 55
 Radanović · 26
 Radmilović · 53
 Radovanović · 45, 46, 48
 Ramazzotti · 18
 Riboli · 39
 Ristić · 44, 52, 53
 Roddis · 24
 Rojas Rodríguez · 49
 Rucker · 40
 Rybin · 43

S

Savić Šević · 55
 Savić-Šević · 59
 Scherbinin · 43
 Scholtes · 40, 57
 Setzpfandt · 35, 61
 Sorelli · 18
 Stanojević · 45, 46, 48
 Stefanović · 52, 53
 Stevanović · 55
 Stojanović · 31, 34
 Stojković · 46
 Stolz · 40
 Strelkova · 42
 Suraci · 36

T

Taddei · 36
 Tirloni · 36
 Tkach · 42
 Todorović · 55
 Tomić · 16

Topalović · 46
Torrini · 49, 59

U

Ushakova · 43

V

Vadimovich · 42
Vedernikova · 43
Vilella · 18
Vučetić · 53

Vukcevic Stojiljkovic · 61
Vuković · 45, 46, 48

W

Wickenbrock · 60
Wittkämper · 40

Z

Zibar · 41
Živić · 55
Zoli · 18