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(Conference)

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Conference program

Sunday, March 12th

Chairman: Branislav Jelenković

16.00 – 16.30	**Registration & opening**
16.30 - 17.00	**Goran Mashanovich** *Mid-Infrared Silicon Photonics for Sensing*
17.00 - 17.20	**Bratislav Marinković** *"Photoelectron" Spectroscopy by Electron Impact: Scattered and Ejected Electrons*
17.20 – 17.40	**Danka Stojanović** *Data enrichment and calibration for PM 2.5 low-cost optical sensors*
17.40 – 18.00	**Dušan Božanić** *Valence Band Electronic Structure of Azobenzene-Functionalized Gold Nanoparticles*
18.00 – 18.15	**Duška Popović** *Analysis of the photoelectron energy spectra at resonant two-photon ionization of hydrogen atom by intense short laser pulses*
18.15 – 18.30	**Vladimir Damljanović** *Atlas of electronic band structures in two-dimensional materials*

Monday, March 13th

Chairman: Zoran Grujić

16.00 - 16.30	***Refreshment***
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17.00 - 17.20	**Vladimir Đoković** *Gold-riboflavin hybrid nanostrucutures as possible photodynamic therapy agents*
17.20 – 17.40	**Nikola Stojanović** *Femtosecond laser spectroscopy for Exploration of Space*
17.40 – 17.55	**Merve Ekmekçioğlu** *Properties of Multilayer ZTO/Ag/ZTO Thin Film Electrodes Deposited by Magnetron Sputtering*
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18.10 – 18.25	**Miloš Davidović** *Combining size distribution spectrums of ambient aerosols using equivalent optical properties of nanosized particles – selected examples from the Bay of Kotor*

Chairman: Bratislav Marinković

20.00 - 20.30	**Robert Loew** *Making hot atoms interact*
20.30 - 20.50	**Predrag Tadić** *Photoplethysmogram as a source of biomarkers for AI-based diagnosis of heart failure*
20.50 - 21.10	**Gulnur Aygun Ozyuzer** *The Effect of ZTO Interlayer Between LCO and LLZO Used in All Solid State Batteries*
21.10 - 21.25	**Mirjana Stojanović** *Localized modes in linear flux dressed two-dimensional plus lattice*
21.25 – 21.40	**Nataša Bon** *The Investigation of The Central Activity and Stellar Population Parameters in Active Galactic Nuclei*
21.40 – 22.00	**Edi Bon** *Spectroscopic modeling of supermassive binary black hole orbits in active galactic nuclei*
22.00 – 22.15	**Aleksander Kovačević** *Beam modification during propagation through aqueous microalgae suspension of interest to waveguiding*

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Chairman: Ljupčo Hadžievski

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17.00 - 17.20	**Branislav Jelenković** *Squeezed light by FWM in alkali vapor – generation and application*
17.20 – 17.40	**Caterina Credi** *Straightforward integration of SERS technology within novel opto-fluidic devices for rapid liquids probing with high sensitivity*
17.40 – 18.00	**Sara Nocentini** *Temperature-controlled polymer nanopatterning for 4D tunable photonics*
18.00 – 18.15	**Jovana Petrović** *Ultra-low-loss broadband multiport optical splitters*
18.15 – 18.35	**Mehtap Ozdemir** *Optimization of Large Area Thin Films for All Solid State Electrochromic Devices*

Chairman: Ivana Drvenica

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20.30 - 20.50	**Ljiljana Nikolić** *Application of optogenetics for studying neuronal activity via glial photostimulation*
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21.10 – 21.25	**Marija Ćurčić** *Response of a scalar Mx magnetometer to the transverse modulation of magnetic field*
21.25 – 21.40	**Aleksandra Milenković** *Affordable VCSEL diode laser for high resolution spectroscopy of cesium D1 line*
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Spectroscopic modeling of supermassive binary black hole orbits in active galactic nuclei

Edi Bon[1], Nataša Bon[1] and Paola Marziani[2]

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Abstract. Supermassive black holes (SMBH) are expected to originate in the core of every galaxy. In the process of merging of galaxies, their SMBHs eventually should end up in very close orbits. Such configurations, supermassive binary black hole (SMBBH) systems, are expected to produce extreme energies, as well as gravitational wave emission (see [1], [2], [3]). Sources should be highly variable (see for e.g., [4]), photometrically and spectroscopically. Monitoring of the variable emission originating in proximity of central SMBHs in cores of some galaxies could allow us to search for possible candidates of SMBBHs. Here we present an analysis to identify several SMBBH candidates, using very long term photometric and spectroscopic observations. We also present orbital elements of SMBBHs obtained with a toy model developed under the assumption that their variability time scales correspond to the orbital ones ([1], [2], [3], [5]).

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The Investigation of The Central Activity and Stellar Population Parameters in Active Galactic Nuclei

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Abstract. Active galactic nuclei (AGN) show plenty diversities in their spectra – emission lines differ strongly in their widths, intensities, shapes, shifts; continuum has different slopes and intensities; host galaxy could contribute to featureless AGN continuum, or it is almost invisible… All these variety in AGN spectra make spectral analysis and any systematization of the spectral parameters additionally difficult. In order to analyze spectra of active galactic nuclei (AGN), we made a model that cover all spectroscopic components of integrated light in the optical domain. We investigated the characteristics of stellar populations (SP) in the central kiloparsec of active galaxies. Here we present our results from the simultaneous analysis of central activity and SP components in Type 1, but also in Type 2 AGNs. Simultaneous analysis of all components of integrated light from AGNs observed on different telescopes may provide an unique possibility to investigate objects in an uniform way.

Making hot atoms interact

Robert Loew

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Abstract: The research and the spectroscopy of hot vapors carries great potential, ranging from fundamental research to robust applications in the context of quantum technologies. In the past decades the spectroscopy of atomic and molecular gases at room temperature has lost some attention due to the focus on cold atomic systems. Still, due to their experimental simplicity, their robustness, and their fundamental nature, they hold the promise to realize real-world quantum devices. Their narrow-band transitions and high optical depths enable such vapor cell science to implement excellent sensors, references, metrologic devices or building blocks in quantum optics.

In this talk I will focus on optical non-linearities induced by atom-atom interactions, either by highly excited Rydberg states or for low lying states via the resonant dipole-dipole interaction. These non-linearities are manifest at the single photon level and can be exploited to generate and process non-linear light fields. As a platform we us a variety of cell types and excitation schemes, where the most advanced ones involve integrated photonic waveguides and microresonators.

Atlas of electronic band structures in two-dimensional materials

V. Damljanović[1], N. Lazić[2]

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Abstract. We have extended our previous work, devoted to full enumeration of layer groups and Brillouin zone high symmetry points hosting fully linear dispersions [1], to include dispersions beyond linear ones near all high symmetry points and lines for non-magnetic materials without and with spin-orbit coupling. Our results are presented graphically and fit into only two figures and a few pages of text/formulas [2]. Our graphical presentation enables easy access to information regarding which parts of Brillouin zone host particular quasiparticle in a certain layer (single- or double-) group.

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"Photoelectron" Spectroscopy by Electron Impact: Scattered and Ejected Electrons

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Abstract. Scattering experiments, as well as corresponding theory, have played an important role in uncovering the nature of physical, chemical and biological phenomena at the atomic and molecular level. Through the interactions of the impinging quantum particles, either photons, electrons, ions or any other well characterized entity, with the target, it has been possible to gain knowledge on internal structure or dynamics of the system. Using lasers [1] or synchrotrons [2] as sources of well-defined photons (frequency, polarization) one can provide a detailed understanding of complex system. But nothing less useful could be electrons as projectile particles used instead of photons [3]. Nevertheless, electrons are considered as multipole interacting particle, there are certain conditions when they behave as dipoles (analog to photons) [4]. A quantitative relationship between fast electron impact and the absorption of electromagnetic radiation had been established, showing that fast electrons at the optical limit (i.e., $K^2 \to 0$, K ‘ momentum transfer), could make quantitative "optical" measurements in which the energy loss, ΔE, simulates the "photon" energy. Using conventional techniques of electron energy loss spectroscopy at high impact energies absorption spectra have been obtained for both valence shell [5] and inner shell [6] electrons. Especially it is interesting an interplay (interference) between scattered and ejected electrons [7].

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Localized modes in SSH photonic lattice in the presence of defects and local nonlinearity

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Abstract. One of the simplest [1] and nowadays hugely investigated models [2-5] for which topological features can be determined is the one-dimensional SSH (Su–Schrieffer–Heeger) model. In photonics, it can be realized as a waveguide array with alternating values of coupling between waveguides, Figure 1. While the linear regime has been investigated in great detail, the nonlinear regime leaves a number of questions open and is the subject of the work presented here. The light propagation through the waveguide array is mathematically modeled by the tight-binding differential-difference Schrödinger-like equation and numerically solved by the 4th order Runge-Kutta procedure. By tuning the ratio between the coupling constants of neighboring sites in the lattice, a topological phase transition can be induced. Boundary-bulk correspondence then provides creation of an integer number of edge states and the response of the bulk via integer value of the Zak-phase. We play with adding defects and inducing the nonlinear lattice response in order to confirm existing and find and manage new topological transitions in the system. This has potential applications in realization of the basic logic gates with controlled light (classical and quantum) beams which are necessary for solving quantum computing issues.

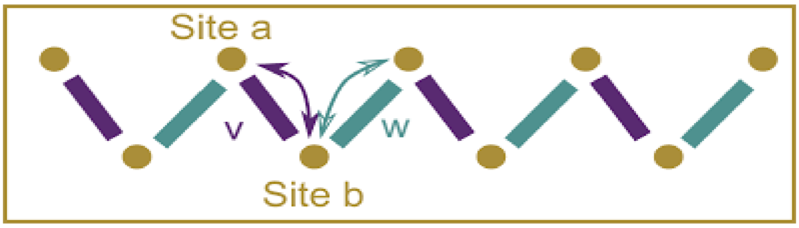

Figure 1. Schematic presentation of the bipartite SSH lattice with unit cell consisting of two sites a and b. The alternating coupling constants are denoted by v and w, respectively [1].

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Temperature-controlled polymer nanopatterning for 4D tunable photonics

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Abstract. Responsive polymers with a 3D nano structuration allow for functional microstructures with a wide range of applications in tunable photonics. Among responsive materials, liquid crystal based polymeric formulations, thanks to the reversible shape change and refractive index variation, open for a dynamic tuning of the optical properties by external stimuli. The photonic structure morphology can be finely controlled in elastic materials such as liquid crystalline networks (LCNs).[1] LCN are defined as "artificial muscles" and their anisotropic deformation can be programmed by a proper molecular alignment design with a sub-millisecond dynamics.[2] The 4D microstructuration (3D design with a well-controlled temporal deformation) is achieved by photo-polymerization of smart materials with Two photon Direct Laser Writing (TP-DLW).[3] We explored all these ingredients in the field of polymer photonics to fabricate a 2D diffractive grating structure for optical beam steering with sub-millisecond time response[2] and tunable whispering gallery mode resonators (WGMR) integrated in photonic circuits for dynamic signal manipulation and filtering.[4] 3D nanofabrication of more complex soft photonic structures requires an advanced control over the lithographic parameters. To this end, we showed as controlling the polymerization temperature of LCN is possible to obtain the same lithographic performances in terms of resolution and structure stability (still preserving their elasticity) than glassy commercial polymers.[5] This open to the realization and optical characterization of 4D photonic crystals responsive to temperature variations.

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Ultra-low-loss broadband multiport optical splitters

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Abstract. Conventional designs of multiport splitters rely on concatenation of directional couplers or multimode interference [1, 2]. However, the splitters show a considerable insertion loss and fast bandwidth drop with the number of ports. Inverse nanodesigns enable broad-bandwidth semiconductor splitters, however, at high fabrication and design costs [3, 4].

In this work we present efficient and low-cost inverse design and experimental realization of multiport splitters with near-zero insertion loss, broad bandwidth and small footprint. Design is based on single-mode linearly coupled waveguide arrays which support periodic light propagation [5]. It allows for realisation of arbitrary splitting ratios by simple adjustment of waveguide separations.

To demonstrate the technique, we designed equal 1×N power splitters and fabricated them in a borosilicate wafer by femtosecond laser writing method. The splitters show zero insertion loss within the experimental error, bandwidth of 20−60 nm and low imbalance < 0.5 dB. Their footprint scales exponentially with the waveguide separation, which can be reduced to the limit of mode confinement. Remarkably, the splitting ratio can be wavelength and array-length tuned.

The proposed splitters offer new possibilities for path-entanglement generation, multipath interferometery on chip [6] and spatial mode multiplexing [7].

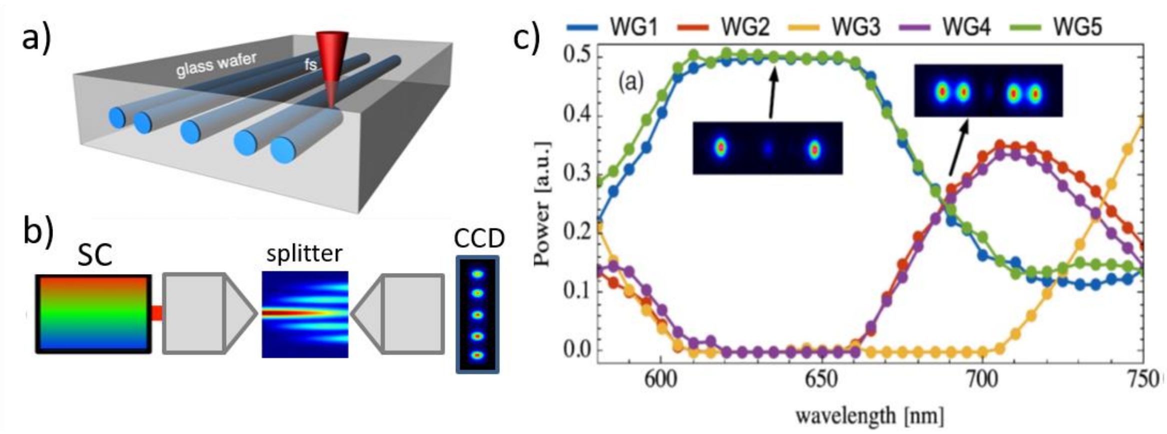

Figure 1. (a) Femtosecond laser writing technique. (b) Splitter testing setup and output light intensity recorded on CCD. (c) Demonstration of the splitter multifunctionality.

We acknowledge the support from the Ministry of Science RS, Grant No. 451-03-47/2023-01/200017.

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Thermoelectric temperature control of *Morpho* butterfly wings used for radiation sensing

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Abstract. Because of their unique optical properties, Morpho butterfly wings inspired development of a range of novel sensors in the past decade [1]. Radiation detection proved to be particularly interesting, as it was shown that Morphos can detect the infrared part of the spectrum with no need for detector cooling [2,3]. Among the proposed techniques for optical readout of the radiation induced changes, digital holography was the only one to demonstrate image acquisition using a *Morpho didius* wing [4]. In our research, we built upon the principles used for holographic interrogation of the *Morpho* butterfly imaging sensor and developed an experimental setup for thermoelectric (TEC) temperature control of wing's back surface. We used the setup to determine a range of temperatures yielding the optimal sensor holographic response to 5 mW, 632.8 nm laser radiation. The setup used a PSoC 5LP (Programmable System-on-Chip) microcontroller based PID regulator with a Howland current pump [5] for TEC control and LM35 pn junction analog temperature sensor for temperature feedback monitoring, as shown in Figure 1. We investigated both TEC heating and cooling of the wing and observed a change in dynamics of the optomechanical response of the wing scales. A temperature variation of the wing's back surface outside of the range of ±15°C compared to the ambient resulted in a decrease in sensitivity of 20% or more, while no improvement in the frequency bandwidth was observed. The optimal range of wing's back surface temperatures is concluded to be between 15 and 35°C.

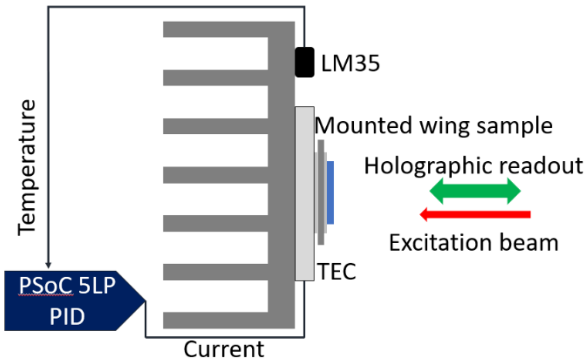

Figure 1. A setup for temperature control of a holographically interrogated Morpho wing radiation sensor.

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The Role of Physics in Modern Neuroscience

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Abstract. Experimental medicine moves forward only when a new experimental method is developed to allow measurements that were previously unattainable with old methods. In medicine, the delicate and complicated structure of the brain represents a major barrier for understanding the causes of psychiatric and neurological diseases. The same forces that prevent understanding of the brain functions, also prevent development of effective therapies that can rid mankind of devastating diseases such as schizophrenia, Huntington's disease, or Alzheimer's disease; to mention just a few of the most debilitating examples with very poor prognosis. Understanding of cellular/molecular mechanisms underlying brain functions such as cognition and emotions requires monitoring of membrane voltage at three levels: the cellular, circuit, and system levels. Seminal voltage-sensitive dye and calcium-sensitive dye imaging studies have demonstrated parallel detection of electrical activity across populations of interconnected neurons in a variety of preparations. A game-changing advance made in recent years has been the conceptualization and development of optogenetic tools, including genetically encoded indicators of voltage (GEVIs) or calcium (GECIs) and genetically encoded light-gated ion channels (actuators, e.g., channelrhodopsin2). I will discuss the contributions of biomedical engineering in modern experimental neuroscience, with a special emphasis on optical imaging of the neuronal electrical activity. In addition to a technological overview of the challenging experimental questions and experimental designs, I will show our recent experimental data on recordings made from two different classes of neurons inhabiting the mammalian cerebral cortex (excitatory and inhibitory cells). By combining optogenetics and neurophotonics, we made voltage imaging from: [i] excitatory pyramidal neurons or [ii] inhibitory interneurons. I will also discuss how novel approaches based on GEVIs (and GECIs) coupled with genetically encoded actuators (e.g. channelrhodopsin or halorhodopsin) will promote progress in our knowledge of brain circuits and systems.

Femtosecond laser spectroscopy for Exploration of Space

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Abstract.

Space agencies around the world have the exploration of solar system bodies in the focus of their activities for decades already. The search for traces of life and to a better understanding of the geology of planets, moons and asteroids motivates these explorations. Our (DLR institute for Optical Sensor Systems (DLR-OS)) contribution to this topic is the development of spectroscopic sensors for material identification. DLR-OS is developing a wide range of spectroscopic sensors that reach from passive infrared spectrometers for remote sensing employed on orbiters to active laser spectroscopies such as NIR spectroscopy, Raman spectroscopy or Laser-Induced Breakdown Spectroscopy that are employed on robotic lander missions. Space, weight and power restrictions as well as robustness against harsh environmental conditions are inherent prerequisites for space missions and lead to specific design solutions for these instruments. Driven by emerging technology of space ready short-pulsed (femtosecond) lasers we are introducing the new topic of time domain spectroscopies to space exploration. In this work, we present our first results on coherent phonon and THz time domain spectroscopies on space relevant minerals.

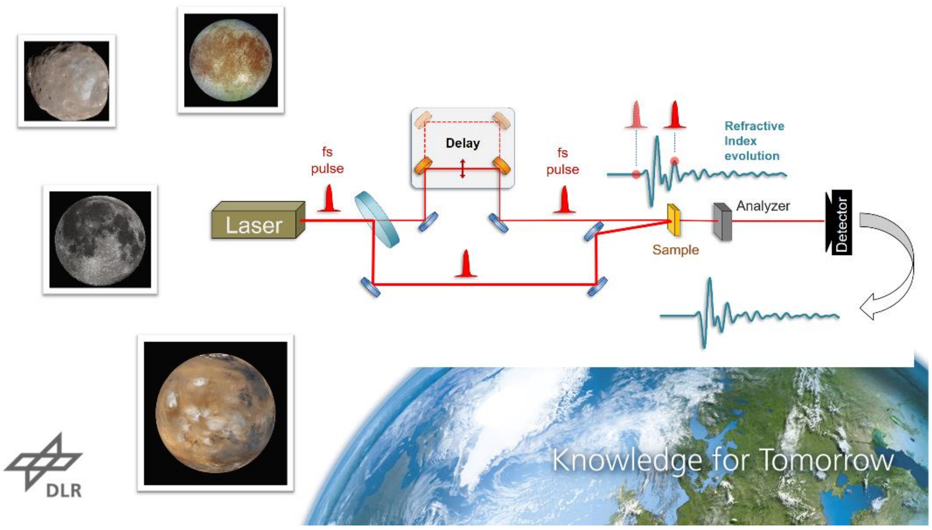

Figure 1. Coherent phonon spectroscopy on space relevant mineral material.

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Impact of the vortex distortion phase on the efficiency of lasing zero-mode

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Abstract. Photonic lattices of optical waveguides present a well-controlled platform for investigation of different phenomena associated with the topological characteristics of physical systems. Recently, the first experimental realization of a Majorana zero-mode bound at vortex-like distortion induced in the bulk of a 2D graphene-like photonic lattice is demonstrated in [1]. The observed modes lie mid-gap at zero energy and they are extremely robust to the perturbations to the underlying Hamiltonian. We use bipartite armchair hexagonal lattice and create a vortex topological defect by perturbing positions of the central waveguides and numerically examine how the eigenvalues spectrum depends on the distortion phase. The observed robustness of zero-mode is an indication that adding the saturable gain and linear loss to lattice can lead to efficient lasing. Starting from the noisy background, we achieve zero-mode lasing, shown in Figure 1. We further investigate its robustness to the changes in driving conditions and the vortex phase with the goal to find an efficeint and steady lasing regime. These results can be used to design a new topological laser.

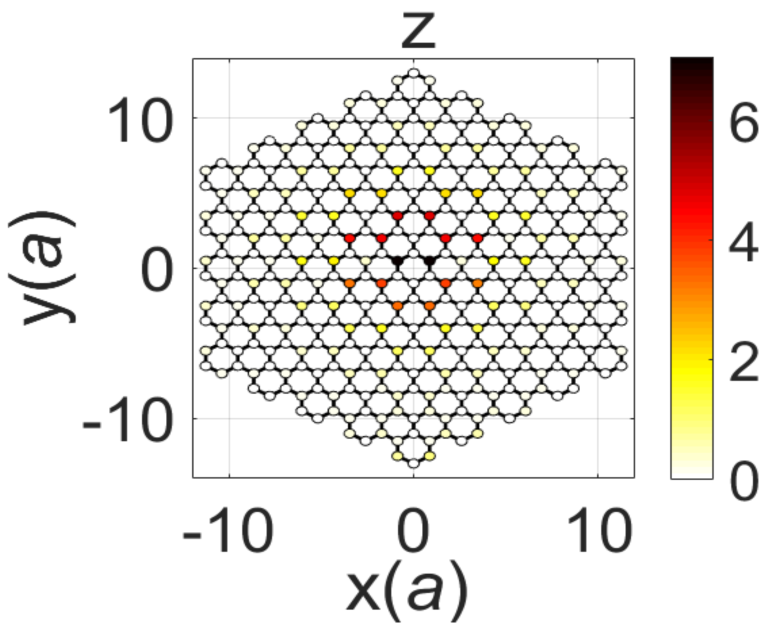

Figure 1. An example of the efficient lasing zero-mode initiated from the noisy background in hexagonal-shaped lattice with a vortex-like distortion.

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Photoplethysmogram as a source of biomarkers for AI-based diagnosis of heart failure

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Abstract. We present our progress on the "Multi-SENSor SysteM and ARTificial intelligence in service of heart failure diagnosis (SensSmart)" project, which was introduced at the last year's edition of the Workshop [1]. The goal of the SensSmart project is to enable early diagnosis of heart failure, through the development of: 1) a multi-sensor polycardiograph apparatus (PCG) that produces simultaneous acquisition of the subject's electrocardiogram (ECG), photoplethysmogram (PPG), heart sounds, and heart movements, and 2) AI-assisted analysis of the acquired signals.

This presentation is going to focus on the acquisition and processing of PPG signals. PPG is obtained by using a pulse oximeter which illuminates the skin and measures the changes in light absorption, thereby enabling the detection of blood volume changes in the vessels. Our PCG apparatus measures the blood flow through the brachial, radial, and carotid arteries. During each heartbeat, the generated waveform typically exhibits several characteristic points [2]. The magnitudes and time distances between these points are useful indicators of many cardiac conditions, including heart failure [3]. However, the inter-patient variability of the PPG waveform makes it challenging to derive simple rule-based diagnostic procedures. This has led many researchers to turn to statistical or machine learning methods for processing of PPG signals [4].

In this presentation, we give an overview of AI-based signal processing methods for PPG, and present some preliminary results and challenges in extracting features from real-world signals obtained using our PCG.

This 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. We acknowledge the support from the Ministry of Science RS, Grants No. 451-03-47/2023-01/200017 and 451-03-68/2022-14/200103.

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Autocorrelation for denoising biomedical signals

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Abstract. Photoplethysmography (PPG) has become a standard method for assessment of blood volume changes in clinical care and heart rate in home care [1]. Besides the pulse rate, PPG pulse forms carry signatures of diagnostically relevant events in cardiac cycle and can be used to estimate arterial stiffness. Extraction of these features requires removal of noise, motion artifacts and the superimposed slow varying signals, such as that from breathing, from the signal while preserving pulse morphology. However, modern filtering methods often fail to reproduce all signal features.

Here, we propose a novel noise–removal method based on autocorrelation. Autocorrelation is a well-known method used in optics, mainly for estimating the duration of ultrashort laser pulses. We used autocorrelation to remove the noise and baseline wander (BLW) from a set of bioelectrical signals, namely electrocardiogram (ECG) and PPG. These signals comprise pulses (or beats) repeated in time but with slight changes. When we record several such beats and by averaging them get a noise-free signal with distorted morphology. However, taking a few steps further, namely subtracting the average from the original signal and filtering the difference in the frequency domain, enables the noise and BLW extraction from the original signal and reproduction of a faithful noise-free signal. We tested this method on the private ECG database, where added BLW component is from public MIT-NST database, and on the private PPG signals. The results show the superiority of our approach compared to the conventional cubic spline (CSP) method.

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Combining size distribution spectrums of ambient aerosols using equivalent optical properties of nanosized particles – selected examples from the Bay of Kotor

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Abstract. Atmospheric aerosols in urban areas typically consist of particles of different diameters, which can range in size from a few nanometers to a few micrometers and can have a strong impact on human health [1,2]. This motivates the need to measure aerosol concentration accurately, but it is often also necessary to combine results from several instruments, with fundamentally different measurement principles. In this work, methods based on the measurement of the electrical mobility of particles, for the range of diameters from 10nm to 420nm, and the measurement of the equivalent optical diameter, for the range of diameters from 300nm to 10um, were used. Combining the overlapping region in two size distribution spectra can be used to infer equivalent optical properties of the ambient aerosol, and examples of measured and combined spectra in several urban hot spots in Bay of Kotor are analyzed in some detail. These examples will illustrate several aspects of urban aerosol properties not readily available in a typical regulatory monitoring setting, such as distribution of modes in number and mass concentration, as well as optical properties of measured aerosol.
As the main result, examples of combining particle size spectrums are presented. In the process of combining the particle size spectra, it is possible to modify the distribution obtained by optical measurements by searching for the optimal value of the refractive index of the particles to obtain the best possible agreement with the size distribution obtained by measuring the electrical mobility. An equivalent refractive index as well as the equivalent shape factor of the ambient aerosol is obtained using Mie scattering theory as a theoretical framework [3]. The measurement results from the mobile monitoring campaign in Bay of Kotor in 2017 were used to elucidate the main principles of size spectrum combination, as well as to showcase diversity of equivalent optical properties of urban aerosols.

Funding for this work has been provided by the EU H2020 Framework Programme for research and innovation under grant agreement no 952433 (VIDIS); Ministry of Education, Science and Technological Development of the Republic of Serbia under contract number 451-03-47/2023-01/ 200017 which is being realized in Vinca Institute of Nuclear Sciences.

Keywords: electrical mobility; equivalent optical diameter; Mie scattering; log normal distribution

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Optical methodologies in the analysis of erythrocyte deformability and heterogeneity

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Abstract. Ektacytometry, a diffraction-based method, measures the deformability of entire erythrocyte populations and does not provide information on the altered deformability of individual erythrocytes or affected subpopulation induced by constant oxidative stress, physical stress, metabolic depletion, and loss of ion gradients during their 120 days life span. We introduced an approach based on ektacytometry coupled to flow cytometry analysis to monitor the deformability and heterogeneity of subpopulations of erythrocytes. The effects of *in vitro* changes of osmotic gradient (from 155 mM to 93 mM phosphate buffer) and treatment by oxidative agent (0.5 mM and 0.75 mM terc-bytil hydroperoxide (TBPH)) on human erythrocyte isolated from healthy male donors, were tested using RheoScan D 300 (RheoMeditech. Inc., Korea) and BD FACSCalibur flow cytometer (Becton Dickinson, USA).

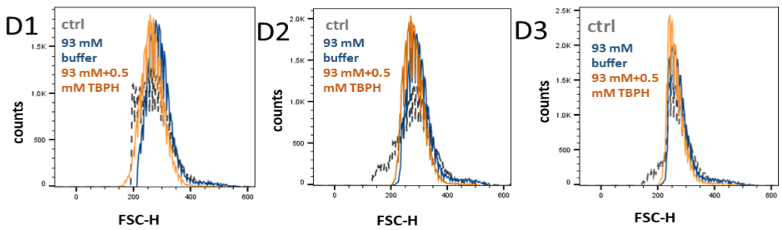

Figure 1. Effect of *in vitro* swelling and oxidation on erythrocytes FSC distribution (D-donor)

A decrease in erythrocyte deformability by changes in osmolality or treatment with TBPH *per se* was demonstrated by ektacytometry. Nevertheless, this method could not analyze the erythrocytes that underwent both treatments due to their lysis by the shear stress in the device. The samples of an equal population of normal erythrocytes and erythrocytes rigidified by 0.5 mM TBPH (slightly rigid) showed elongation indices in the physiological range, i.e., the effect of the treatments was annulled. The same result was obtained by flow cytometry. On the other hand, an altered population of oxidized cells by 0.5 mM TBPH was detected in hypoosmotic 93 mM buffer based on their forward scatter (FSC) (Figure 1) and side scatter (SSC) parameters. The subtle changes in the erythrocyte's subpopulation mechanobiology are essential to monitoring even in healthy people exposed to physical or/and environmental stress and stored erythrocytes, but some additional techniques are needed for the established optical-based approaches.

Acknowledgement: This study was funded by Science Fund of Republic of Serbia through HEMMAGINERO project (HEMOGLOBIN-BASED SPECTROSCOPY AND NONLINEAR IMAGING OF ERYTHROCYTES AND THEIR MEMBRANES AS EMERGING DIAGNOSTIC TOOL, No 6066079)

The Effect of ZTO Interlayer Between LCO and LLZO Used in All Solid State Batteries

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Abstract., Manufacturing safe, cheap and light energy storage devices has become a challenge and many alternative products have been developed. Among these, all solid state lithium batteries have been under the spot light during the recent years due to their safety, high energy density and high discharge ratio. LIPON, LLTO ($Li_{0.5}La_{0.5}TiO_3$) and LLZO ($Li_7La_3Zr_2O_{12}$) are good examples of good ionic conducting solid electrolytes that have been studied up to now [1]. In present work, we study the interrelation between cathode $LiCoO_2$ (LCO) and electrolyte LLZO thin films. The cathode and electrolyte were grown by RF magnetron sputtering on titanium coated soda lime glass substrates. Thickness of the thin films were measured by surface profilometer and then SEM, EDX, XRD, XPS characterizations were performed. Since the films have grown top of each other, the interface has to show not only low resistance but also high ionic conductivity. In this work, we introduced a Zn_2SnO_4 (ZTO) buffer layer between cathode (LCO) and electrolyte (LLZO). ZTO is a transparent conductive oxide known for its good electrical conductivity and high optical transmittance with superior barrier properties such as low oxygen and humidity transmittance [2,3]. The thin films of LCO/ZTO, ZTO/LLZO and LCO/ZTO/LLZO will be explained with help of X-ray photoelectron spectroscopy (XPS), so we aimed to prove ZTO barrier as a novel interface between LCO and LLZO for all solid state lithium batteries.

Acknowledgments

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Terahertz Metamaterials and Multispectral Terahertz Plasmonic Detectors

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Abstract. Terahertz (THz) wave is being studied rigorously in a wide variety of applications from defense applications to wireless communications [1-2]. Naturally, just like other regions of the electromagnetic spectrum, there is a need to develop frequency tunable or wide bandwidth sources and detectors. Especially for wireless communications, where compared to conventional technologies the THz band would allow for fast wireless data transfer rates there is a need to develop active and passive components that work in the mm wave and terahertz regions. The THz gap can be thought of as a transition between the electronic and optical regions, since metamaterial structures are frequency tunable they can easily be scaled from the microwave to THz region [3-4]. The resonant features shown by metamaterials for different THz frequencies has come about to be an integral part in the development of detection techniques. This is exemplified by the recent efforts of our group where our research and development into high-T_c superconductor metamaterial devices has created a new technological field. First demonstration of graphene and other 2D materials has triggered the development of the next generation optoelectronic devices, such as fast photodetectors. In the proposed study, unique graphene covered mesa metamaterial structures designed and fabricated as photodetector arrays on a single chip. THz lenses are integrated on multispectral photodetector chips. Instead of integrating the metamaterials on the detector separately, the detector itself is consist of mesa metamaterial structures which ensures plasmonic enhancement. The design and optimization of the metamaterials will be performed using numerical simulations aided by CST Microwave Studio program. In the experimental part, the mesa metamaterials are patterned using UV lithography and reactive ion beam etching techniques on silicon substrate. Plasma Enhanced Chemical Vapor Deposition technique is used to deposit graphene layers on the mesa structures. The electromagnetic response of the detectors assessed using both the THz Time Domain Spectroscopy systems and THz continuous wave imaging systems.

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The Characterizations of Thin Film Filters for Far UVC 222 nm Excimer Lamps

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Abstract. Coronavirus pandemics affecting the whole world requires new sterilization approaches, for mostly airborne viruses. Low-pressure vacuum and LEDs lamps have antimicrobial effect at 254 nm emission. However, lamps with a wavelength of 254 nm emit UV radiation and pose a danger to human health, such as skin cancer and cataracts [1]. Far-UVC radiation, $KrCl_2$ excimer lamps of the 222 nm emission display powerful antimicrobial features [2]. UV Radiation at 222 nm can pass through smaller microbes but, its penetration into human cells is minimal thus it cannot penetrate to the key living cells in the epidermis [3]. In our group, we have previously shown that high-efficiency thin-film colored (green, yellow and red) filters based on metal (Ag)-dielectric (ZTO) structure are designed and fabricated on SLG substrates [4]. In present study, we designed optical filters using OpenFilters software for dielectric barrier discharge excimer lamps. The design was aim 222 nm band pass filter. These filters were deposited using 2-inch magnetron sputtering system under high vacuum conditions on quartz substrates. The structure of filters consists of $Si_3N_4/Al/SiO_2$ multilayer thin film layers. The characterization of optical filters was examined using a spectrophotometer in the wavelength range of 200 to 2600 nm. Furthermore, commercial excimer laser was used to analyze our filters using spectrometers. The details of the characterizations and properties of filters will be presented.

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Mid-Infrared Silicon Photonics for Sensing

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Abstract. The mid-infrared (mid-IR) wavelength range is particularly interesting for absorption spectroscopy as many molecules have distinct absorption fingerprints in the mid-IR. There has been a significant progress on the development of mid-IR silicon photonic devices and integrated circuits, primarily for sensing applications [e.g. 1, 2]. The mid-IR silicon photonics group in Southampton has developed several material platforms for different parts of the mid-IR band and reported passive and active devices in those platforms. Lasers, detectors, and modulators have been integrated with silicon and germanium photonic circuits as well as microfluidic channels [e.g. 3]. If a broadband source is used for sensing, then photonic devices operating over a larger wavelength range, such as waveguides, couplers, splitters and detectors (Figure 1) are needed.

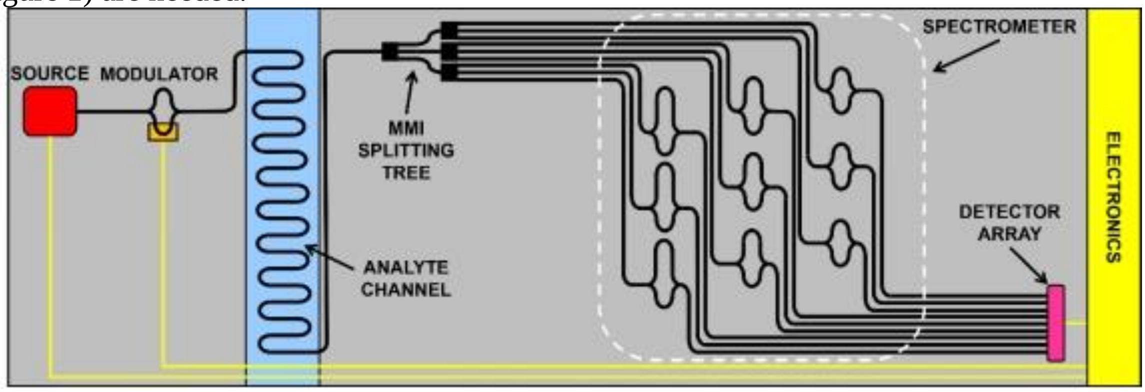

Figure 1. A spectrometer on chip

Broadband silicon waveguides based on subwavelength structures have been designed, fabricated and characterised. They have shown losses of 1.5 dB/cm from 1.95 to 3.8 μm [4]. We have also demonstrated low bend losses in these waveguides. Y-junction and Multimode Interference (MMI) splitters operating with a 600-900 nm bandwidth around a wavelength of 3.8 μm have also been demonstrated [5]. We have fabricated thermally tunable and hybrid on chip spectrometers with spectral resolution of 3.9 nm. Current work focuses on the reduction of footprint and power consumption of such spectrometers. Based on our subwavelength grating suspended Si waveguides, we have shown that mid-IR bolometers can be integrated on Si mid-IR chips [6]. Finally, modulators and sources can be integrated with Si or Ge waveguides and microfluidic channels, forming integrated spectrometers on chip for various sensing applications.

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Fluorescence Correlation and Cross-Correlation Spectroscopy (FCS/FCCS) - versatile tool for quantitative characterization of molecular interactions *in vitro* and *in vivo*

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Abstract. Fluorescence Correlation Spectroscopy (FCS) and Fluorescence Cross-Correlation Spectroscopy (FCCS) are quantitative, confocal laser scanning microscopy-based techniques with single-molecule sensitivity and high spatiotemporal resolution (≈ 250 nm, ≈ 200 ns) that are widely used in molecular biophysics to quantitatively characterize molecular interactions without having to separate the free and bound fraction of molecules [1, 2]. Both techniques record fluorescence intensity fluctuations in a small volume (typically $(0.2 – 1.0)\times10^{-15}$ l) that arise as fluorescent/fluorescently labeled molecules pass through it by free diffusion [3]. As the molecules diffuse through this volume (referred as effective volume), all additional processes that give rise to fluorescence intensity fluctuations at a shorter time scale than diffusion, such as fluorophore blinking due to single/triplet state transition, or alter the time course of fluorescence intensity fluctuations, such as binding to other molecules that slows down diffusion, can also be characterized. Quantitative information about these processes can be extracted from fluorescence intensity fluctuation time series by temporal autocorrelation analysis, and in FCCS also by temporal cross-correlation analysis, to yield information about the: concentration, diffusion (size), fraction and diffusion (size) of free/bound molecules, fraction of molecules in the triplet state and triplet-state depopulation rates [4]. Both techniques are applicable for measurements in solution and in live cells, tissue *ex vivo*, and whole organisms (*e.g.* zebrafish embryo) [5, 6].

I will introduce conventional, single-point FCS and FCCS, give examples of their applications, and discuss about their limitations. In particular, I will present recent development of our home-built FCS instrument and show using ATTO488 in solution how the sensitivity and effective volume size in our home-built FCS instrument are comparable to those in a commercial instrument. I will also discuss about future perspectives of home-built FCS instrument, giving examples of eGFP (enhanced Green Fluorescent Protein) diffusion measurements in live cells.

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Analysis of the photoelectron energy spectra at resonant two-photon ionization of hydrogen atom by intense short laser pulses

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Abstract. We study theoretically the Rabi flopping of the population between the ground and excited 2p states of the hydrogen atom, induced by intense short laser pulses of different shapes and of carrier frequency ω = 0.375 a.u. which resonantly couples the two states, and effects of this dynamics in the energy spectra of photoelectrons produced in the subsequent ionization of the atom from the excited state. It is found that, for Gaussian, half-Gaussian and rectangular pulses, characterized by the same pulse area, the final populations take the same values and the spectra consist of similar patterns (see Fig. 1) having the same number of peaks and approximately the same separation between the prominent edge (Autler–Townes) peaks [1]. These facts disprove the hypothesis proposed in earlier studies with Gaussian pulse [2], that the multiple-peak pattern appears due to dynamic interference of the photoelectrons emitted with a time delay at the rising and falling sides of the pulse, since the hypothesis is not applicable to either a half-Gaussian pulse that has no rising part or a rectangular pulse whose intensity is constant.

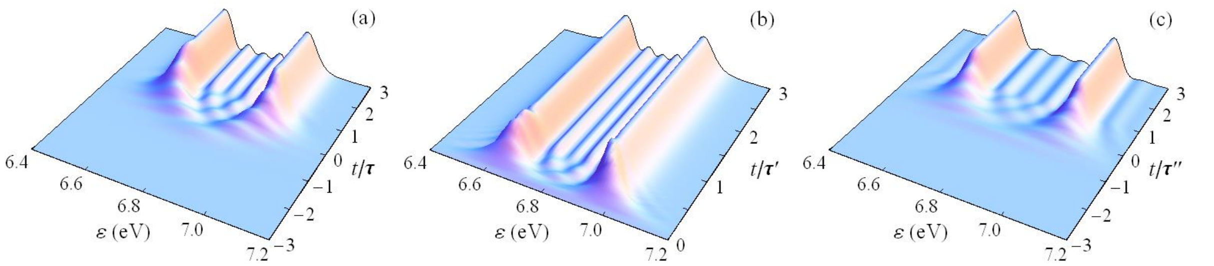

Figure 1. Time evolution of the photoelectron energy distribution (in arbitrary units) during the photoionization process of the hydrogen atom by: (a) Gaussian pulse, (b) half-Gaussian pulse and (c) rectangular pulse of carrier frequency ω = 0.375 a.u. and peak intensity of 12.917 TW/cm^2 at which the atom completes five Rabi cycles during the pulse.

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Effectiveness of two-antenna microwave ablation of large hepatocellular carcinoma

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Abstract. In the treatment of tumors, certain types of cancer cells have been found to denature at elevated temperatures (which are slightly lower than temperatures normally injurious to healthy cells). Conventional microwave ablation techniques for treating hepatocellular carcinoma (HCC) typically used only a single antenna to deliver energy, resulting in relatively small ablation zones and increased risks of local tumor residual, intrahepatic recurrences, or distant metastases. It was shown that two-antenna configurations are less invasive than the single-antenna configuration. Ablation zones created using two antennas are smaller causing less damage to the healthy tissue as compared to those created using a single antenna. Two-antenna configurations produce more uniform thermal profiles and higher peripheral tissue temperatures. Three-dimensional simulation results obtained within the Comsol software package [1] for a) a single-antenna and b) two-antenna microwave ablation of tumor [2] are shown in Figure 1. As can be observed, a single-antenna configuration leads to larger damage to the healthy surrounding tissue. On the other hand, the two-antenna configuration provides complete ablation of the tumor with small damage to healthy tissue.

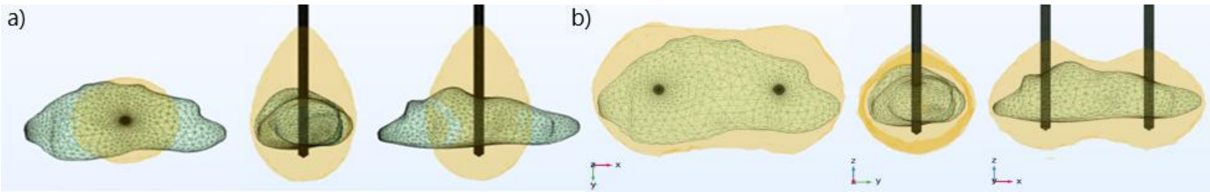

Figure 1. Isocontours related to ablated regions (solid graysurfaces) around the HCC [2] (triangulated surface) after 600 s of a) a single-slot and b) two-antenna microwave ablation.

This research was supported by the support of the Science Fund of the Republic of Serbia, GRANT 7739583, SimSurgery.

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Three-dimensional simulations of the microwave tissue ablation

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Abstract. Microwave ablation (MWA) is a minimally invasive thermal ablation modality based on increasing the temperature above the normal physiological threshold to kill cancer cells with minimal damage to the surrounding. The objective of the study is to assess the role of optimal conditions in the efficacy of MWA in treating malignant tissues. For this purpose, a three-dimensional simulation model is developed and tested within the COMSOL Multiphysics software package [1]. Figure 1a shows the liver (triangular surface) with early-stage HCC (1.64 cm × 1.71 cm × 3.81 cm) (solid red surface) of patient 16 (male, born in 1950) in the 3D-IRCADb-01 database [2]. The proper choice of input power should be estimated before the procedure begins to attain the desired ablation zone. As can be seen from Figure 1b, when a power of 10 W was applied, the tumor was not completely ablated. Application of 15 W to the significant damage to healthy tissue. The application of 13 W provides treatment for the entire tumor with minimal damage to the surrounding tissue [3].

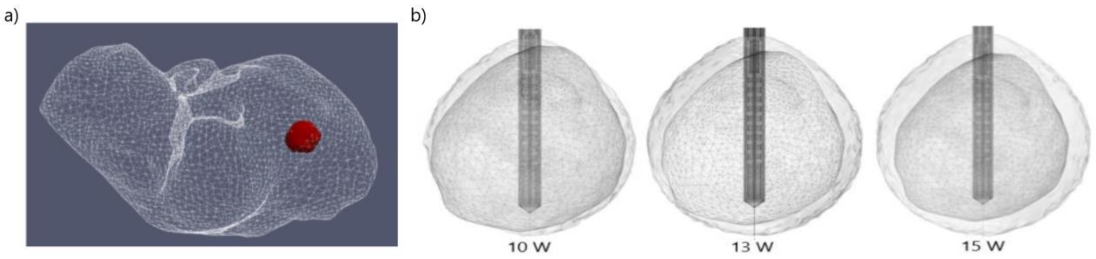

Figure 1. a) Three-dimensional simulation model of HCC (solid red surface), which belonged to patient 16 in the 3D-IRCADb-01 database [2] and b) ablated regions (solid grau surfaces) around the HCC [2] (triangulated surface) after 600 s of microwave ablation at 2.45 GHz and three different values of the input power.

This research was supported by the support of the Science Fund of the Republic of Serbia, GRANT 7739583, SimSurgery.

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Localized modes in linear flux dressed two-dimensional plus lattice

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Abstract. Flatband (FB) photonic lattices represent ideal testbed for studying transport and localization properties at the linear level in diverse physical systems [1]. Photonic lattices are easy for manipulation and investigation of wave dynamics. The photonic lattices offer an ability to design artificial gauge field effects which are equivalent to the magnetic field flux and the spin-orbit interaction in atomic systems [2].

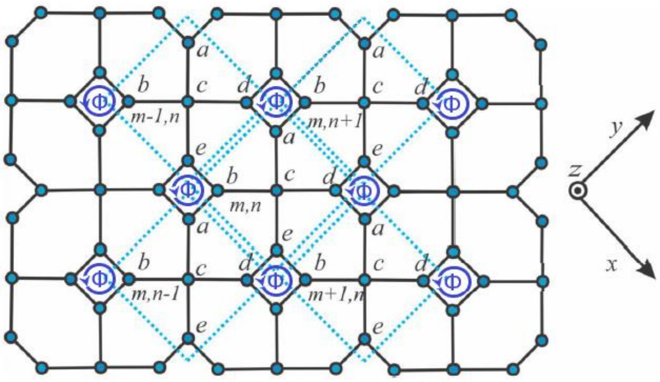

Figure 1. Schematic of 2D plus-like lattice with artificial flux. The unit cell is encircled by a dotted line.

The two-dimensional (2D) plus lattice [3] dressed by the artificial flux can be experimentally realized by techniques based on the coupled-spring resonators [4] and wave-guide networks [5]. Here we tuned the artificial flux values and studied their effect on the energy band spectrum and we were trying to find compact localized modes (CLMs).

The geometry of the uniform plus lattice dressed by the artificial flux is Figure 2. Schematic of 2D plus-like lattice with artificial flux. The unit cell is encircled by a dotted line.schematically presented in Fig. 1. The unit cell consists of five sites, linearly coupled with each other with the same intra-cell coupling constant. The flux of the artificial field modifies the coupling between different unit cell sites to $t\cdot\exp(\pm i\phi/4)$, where t is the hopping parameter and ϕ is the artificial flux. In the absence of flux, in the uniform lattice, the energy spectrum has one fully degenerate FB, centered at zero, and four dispersive bands (DBs) [3]. We have found that this lattice can host the Aharonov-Bohm effect for certain flux values [6]. When diamond plaquettes are dressed by artificial flux $\phi=\pi$, this lattice spectrum is described by two momentum independent, fully degenerated FBs, and three DBs. Corresponding CLMs have been obtained. In the comparison with the flux-free case, we found three different types of fundamental non-orthogonal CLMs now. These CLMs occupy 5 unit cells i.e. are class U=5. The central site amplitude is zero and all other 4 sites of unit cell have nonzero amplitudes.

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Proposal for a new surveillance system for military vehicles and a new crew arrangement

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Abstract. New wars require new solutions for military vehicles crew protection. We have seen unsuccessful attempts by Russian constructors. I will present solution for a new vehicle observation system and a crew protection suit.

Modeling of optical properties of novel terahertz photonics quantum well heterostructures

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Abstract. In this contribution, we present our recent work on modeling intersubband transitions in the conduction band of semiconductor-based quantum well structures [1], [2]. Particularly interesting are possibilities offered by ZnO/ZnMgO and La-doped BaSnO3/BaO perovskite-oxide for the realization of room temperature oxide-based THz quantum well optoelectronic devices due to their advantageous physical and chemical properties [3], [4]. The electronic structure is calculated self-consistently by solving the Schrödinger–Poisson system of equations. A significant change of the transition energy due to the depolarization shift is also considered in cases when high doping is present. The charge-induced coherence due to the strong dipole-dipole Coulomb interaction between intersubband transitions leads to the formation of multisubband plasmons and a complete quantum model [5] based on the dipole representation must be used to calculate absorption spectra.

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Computational modeling of magnetism induced in nonmagnetic 2D materials

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Abstract.

Using density functional theory (DFT) we examined several methods to induce magnetism in 2D materials that are intrinsically nonmagnetic. First, we briefly describe the paramagnetic nature of point defects in graphene and discuss why they can not give rise to long-range magnetic ordering. Then we consider magnetic adatoms adsorbed on 2D materials and indicated approaches to prevent their clustering into 3D nanoparticles. The focus of the study is magnetism induced in borophene upon the adsorption of Fe atoms. Combining DFT with Monte Carlo simulations we described temperature effects on magnetic ordering and estimated the critical temperature of this Fe-based 2D magnet.

Data enrichment and calibration for PM 2.5 low-cost optical sensors

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Abstract. Particulate matter (PM) in air has been proven to be hazardous to human health. Until recently, monitoring of air quality has been done by professional agencies. Nowadays, the availability of portable, low cost microsensor devices and the exponential growth of IoT (Internet of Things) in everyday life has enabled widespread monitoring of air quality among all citizens [1]. For PM measurements, optical sensors measure light scattering by particles carried in an air stream through a light beam, which is converted by computation to equivalent mass concentration. Light scattering is strongly affected by parameters such as particle density, particle hygroscopicity, refraction index, and particle composition [2].

In this study, we measured PM 2.5 by seven AQ MESH low-cost optical sensors and compared the measured data with the ones obtained from the reference monitoring station (SEPA). Could we, by a sequence of low-processing data enrichment and a simple calibration method, reach an accuracy as close as a calibration based on machine learning? To answer this question, we used low-processing data enrichment such as resampling, encoding periodic time-related features and making a composition of the initial low-cost signal at different time scales. We compared two algorithms for the calibration: multivariate linear regression and random forest. The results gave promising results and encouraged us in researching further about signal low-processing to achieve the required quality of data from low-cost sensor devices monitoring air quality [3].

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Electromagnetic Induction Imaging with Atomic Magnetometers: Pushing the Boundaries

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Electromagnetic induction imaging (EMI) allows mapping of the conductivity of target objects and, when combined with appropriate algorithms, the generation of full 3D tomographic images. Despite its tremendous potential, and the wealth of possible applications, the use of EMI has essentially been limited to eddy current testing for monitoring of corrosion and welding in metallic structures.

This talk discusses the factors hindering the progress of electromagnetic induction imaging and highlights how the use of atomic magnetometers overcame some of them, opening the path to new applications of EMI. Our results on sub-S/m imaging are presented, and their implication for biomedical applications discussed. Very recent results on rapid imaging and two-photon EMI are illustrated, and their implications for the deployment of EMI systems in real-world applications discussed.

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Straightforward integration of SERS technology within novel opto-fluidic devices for rapid liquids probing with high sensitivity

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Abstract. Optical detection techniques have been extensively implemented for liquid biosensing and, among all, surface enhanced Raman spectroscopy (SERS) constitutes the one of the most promising analytical methods as alternative to current traditional bioassays [1]. Gold nanoparticles (NPs) with unique physical and chemical properties are exploited as high performing optical transducers that selectively amplify (up to 10^6) the Raman signal scattered from analytes located near NPs [2]. Despite all these advantages, SERS measurements guaranteeing picomolar sensitivity still rely on the exploitation of bulky confocal Raman set-up that cannot be used outside laboratories and leading to uncontrolled evaporation phenomena when tight focusing the excitation laser thus possibly inducing conformational changes of analyzed molecules [3]. To address these issues and to develop accurate portable systems, recent approaches are focused on optofluidics, the science area where photonics and fluidics synergically merge into miniaturized lab-on-a-chip (LoC) devices for light and fluids manipulation at the micrometric scale. Indeed, LoC technology enables easier handling of very small liquid volumes avoiding cross-contamination, efficient NPs-sample mixing and potential separation of NPs-analyte conjugates from the overall matrix based on size variation and diffusion phenomena [4]. In addition, LoCs channels can be exploited to host optical fibers and waveguides for straight light delivering and collection at the fluids level [5]. In the present work, we report on the development of novel SERS-fluidic devices by implementing time- and cost-saving manufacturing processes of advanced fluorinated materials. The exploitation of laser-based 3D printing guarantees high design versatility and thus smart interfacing with compact fiber-based Raman set-ups with embedded optical fibers positioned at different excitation and collection angles to study the effect on collection efficiency. Within the detection chambers, SERS functionality is achieved by the selective interaction of the target analytes with gold NPs of varied size and shape. The resulting SERS-fluidic devices, characterized by different detection configurations, represent highly versatile SERS-fluidic platforms providing high repeatability, high sensitivity and speed of analysis, possibly revolutionizing liquid analysis by making it costless, on-chip, handy, and easy to use.

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Thermal radiation imaging of insects using lockin techniques

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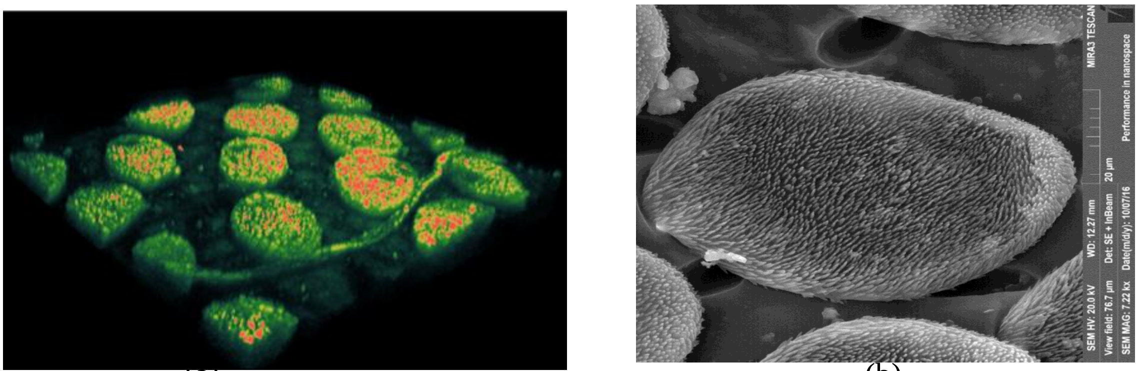
Thermal aspects of life are critically important for the survival of the fittest [1]. Optimal conditions for the biochemical processes within any organism are established using the basic physical principles of thermal energy exchange - convection, conduction and radiation. The last one is the fastest process enabling absorption and dissipation of thermal radiation at the speed of light. Due to the modern techniques of thermal radiation imaging, it is also the most appropriate method for analysis of thermal biology of an organism and its environment [2].

Here we present a simple phase-sensitive method of thermal imaging, enabling detection of small temperature differences. The method is used to analyze thermal response of cuticular photonic structures of insects. A pulsed radiation source is used and synchronized with the frame rate of a thermal camera (FLIR A65). Initial tests were performed with a 532 nm laser pulses irradiating the elytra of *Hoplia argentea* (Poda, 1761). Insect has a curious protective armor (elytron) covered with scales, possessing micro - sized hairs whose dimensions are comparable to the wavelength of thermal radiation at normal environmental temperatures (20 - 40 °C). We have shown that inherent noise of thermal camera is significantly reduced, thus enabling better insight into thermal effects of elytron.



(a) (b)

Figure 1: (a) Cuticular scales of *Hoplia argentea* (recorded using nonlinear microscopy) and (b) their hair-like microscopic structure (recorded on a scanning electron microscope).

Acknowledgment

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In vitro testing of genetically encoded voltage indicator ArcLightD for recording spontaneous electrical activity of cortical neurons

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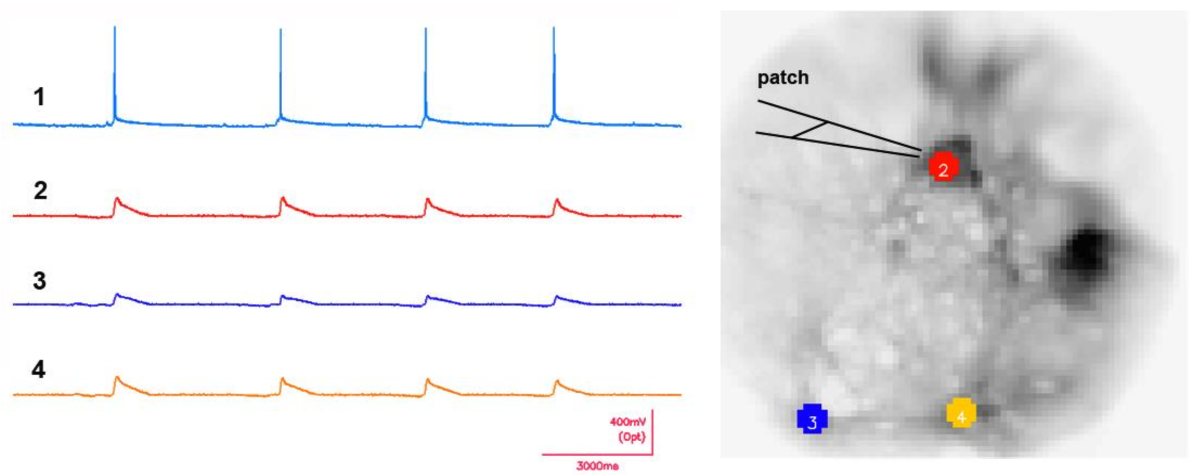
Abstract. Optical imaging techniques, such as calcium and voltage imaging of neuronal activity, are convenient for obtaining information from multiple cells simultaneously. Genetically encoded voltage indicators (GEVIs) show potential in neurobiology and systems neuroscience [1,2], however a major obstacle is the difficulty with the reproducibility of results. Previous work compared different GEVIs under the same imaging conditions, and all produced reasonable optical signals in brain slices and HEK293 cells however they failed to show satisfying results in neurons *in vitro* [3]. In the present study, we aimed to achieve stable expression of GEVI ArcLightD in primary cortical neuronal culture and to use it for testing the potential of immunoglobulin G isolated from amyotrophic lateral sclerosis patients' sera (ALS IgG) as disease biomarker [4,5]. In this respect, we used neurons isolated from cortices of C57BL/6 mouse newborn pups. Four-to-6 days after their isolation and culturing, the mouse neurons were transduced with an AAV vector carrying the ArcLightD GEVI construct. ArcLightD-expressing cells were imaged 7 to 10 days after the AAV transduction. To monitor spontaneous calcium activity, neurons were loaded with a fluorescent chemical calcium indicator Oregon Green Bapta-1-AM via extracellular application. We successfully recorded synchronized spontaneous electrical activity in neurons at the 125 Hz full-frame sampling rate (Figure 1). ArcLightD optical signal transients showed notable variations in amplitude and duration. Blocking of voltage-gated K^+-channels by 4-AP revealed that ArcLightD optical signal is dependent on the ON/OFF kinetic of the action potential and the underlying depolarization. Blockers of synaptic activity DNQX and APV as well as TTX, a voltage-gated Na^+-channel blocker, disrupted spontaneous electrical neuronal activity as expected. Using both calcium imaging and voltage imaging, we tested the effects of ALS-patient IgGs and Control-patient IgGs on spontaneous calcium and electrical activity of cultured cortical neurons. Our data demonstrate successful employment of functional optical imaging with GEVI ArcLightD in recording spontaneous electrical activity from the primary neuronal cell culture and the potential of this method for *in vitro* neuroscientific research.



<u>Figure 1. Simultaneous electrical and optical recordings of membrane potential changes in cultured mouse neurons expressing a fluorescent voltage indicator ArcLightD</u>. The light-blue trace (1. patch electrode recording) and red trace (2. voltage imaging) and are from the cell marked with a label “2”. Dark blue trace 3 and orange trace 4 are optical recordings from two neurons marked by labels “3” and “4”. The image width is 200 micrometers. Schematic drawing marks the position of the glass electrode (patch) attached to the cell “2”.

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Squeezed light by FWM in alkali vapor – generation and application

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Abstract. We present the method for generating amplitude squeezed light (ASL) from twin photon pairs obtained using four way mixing (FWM) in alkali vapors [1], The dependence of ASL on the pump and probe laser detuning, and on the vapor density, obtained in potassium vapor using double-Λ atomic scheme, will be compared with the analytical models. Obtained agreement in certain ranges of FWM parameters, and disagreement in others, will be discussed.
Quantum correlated and entangled photon pairs produced by FWM, or by other methods like SPDC, have been proven in many successful applications. Taking properties of quantum light, quantum sensing and quantum imaging has overcome performances done by classical light, increasing measuring sensitivity by lowering noise below standard quantum limit, SQL. One way of sub SQL images exploits time and mode correlation between twin beams in a differential scheme for noise reduction. We present method of using two-correlated photons microscopy, such as shown in [2], and explain when it will be advantageous over classical two-photon spectroscopy.

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Application of optogenetics for studying neuronal activity via glial photostimulation

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Abstract. Communication between neurons and astrocytes and its role in information processing in the brain has been repeatedly demonstrated over the past two decades. Evidence for neurons communicating with astroglia is solid, but the signaling pathways leading back from glial-to-neuronal activity are difficult to study and remain highly controversial. There is a general agreement that intracellular Ca^{2+} is a key signaling pathway activated in astrocytes in response to neuronal signals. However, it is still debated whether and how intracellular Ca^{2+} contributes to the release of gliotransmitters by astrocytes and to their regulation of synaptic transmission and neuronal excitability [1, 2]. The main limitation causing these controversies is the difficulty to activate astrocytes in a reliable and specific manner. To overcome this we used widespread transgenic expression of light-gated cation channel channelrhodopsin-2 specifically in astrocytes. This optogenetic approach enabled us to control astrocyte activity by the blue light and to study glia-related properties of neuronal activity regulation. Using slice preparations we found that selective photoactivation of astrocytes reliably evoked glial Ca^{2+} responses, increased glutamatergic synaptic transmission in the hippocampus and increased firing of pyramidal neurons [3]. Neuronal firing was regulated by the Ca^{2+}-dependent glutamate release from astrocytes and activation of neuronal extra-synaptic NMDA receptors. Optical activation of astrocytes also increased synaptic transmission through activation of presynaptic metabotropic glutamate receptors in case of pyramidal neurons and presynaptic NMDA receptors in case of granule cells of the dentate gyrus [3, 4]. In this model of blue light stimulated astrocytes, Ca^{2+} increase and subsequent glutamate release were amplified by ATP/ADP-mediated autocrine activation of purinergic P2Y1 receptors on astrocytes. Using optogenetic approach targeting astrocytes we revealed that described autocrine purinergic loop of astroglia is also permanently active in a mouse model of temporal lobe epilepsy and that it sustains abnormal synaptic activity [4]. Moreover, blockade of P2Y1 receptor-mediated signaling in the dentate gyrus astrocytes restored regular glutamatergic synaptic transmission in epilepsy, just as in the case of photoactivated astrocytes. These findings demonstrate that optogenetic astrocyte activation is an effective approach to study glia-to-neuron communication and to understand how it perturbs in disease.

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Properties of Multilayer ZTO/Ag/ZTO Thin Film Electrodes Deposited by Magnetron Sputtering

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Abstract. Transparent conductive electrodes (TCEs) such as Aluminum Zinc Oxide (AZO), Fluorine Tin Oxide (FTO), Zinc Oxide (ZnO) and Indium Tin Oxide (ITO), owing to their high optical transmittance and good electrical conductivity properties, as well as their stability in air, are widely used in many applications such as transparent electronics in LCDs, touch screens, indicators, smart windows, solar cells, photodetectors, electroluminescent devices, organic light-emitting diodes (OLEDs), infrared (IR) reflective coatings [1]. ITO thin film electrode is the most extensively produced and used TCEs because of their high transmittance at visible wavelengths and low surface resistance. However, ITO thin film electrodes used in commercial devices are mechanically fragile and expensive. Additionally, much effort has been devoted to pursuing high-performance alternatives to ITO electrodes, such as Gallium-doped Zinc Oxide (GZO) and Zinc-doped Tin Oxide (ZTO), which have the potential for novel TCEs. Among these electrodes, ZTO thin film electrodes have been shown as the most promising candidate and have been extensively explored in recent years [2,3]. Although ZTO thin film electrodes are extensively used as a single layer, dielectric/metal/dielectric (DMD) multilayers such as ZTO/Ag/ZTO (ZAZ) electrodes have received significant attention for increasing demand for high-performance TCEs [4,5]. In the present study, ZAZ electrodes were deposited on acrylic (Poly (methyl methacrylate)-PMMA) substrates using 2-inch targets of ZTO and Ag with DC magnetron sputtering system. Firstly, we examined high optical transmittance and good electrical conductivity by studying the electrical, and optical properties of ZAZ electrodes. As a result, ZAZ thin film electrode achieved surface resistance of as low as 8 ohm/square and optical transmittance of % 89.2 at 550 nm. Furthermore, we demonstrate that reproducibility of measurements, highly conductive and transmittance ZAZ electrodes with thicknesses of 100 nm were deposited on PMMA substrates. ZAZ electrodes were analyzed by X-ray diffraction and exhibited amorphous structure, and smooth surfaces without any features were observed by scanning electron microscopy. The results show that manufactured ZAZ electrodes can be a good option for many applications.

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Chiral Devices for Terahertz Waves Based on Tunable Metamaterials

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Abstract. There are exceptional advantages in the region where Terahertz (THz) frequency takes place that could be identified as; a non-ionizing bio-innocuous property, transparent characteristics in cardboard or textiles, and extremely discriminating absorption spectral lines which can provide a "genetic code" of various bio-materials. [1,2]. The resonant effects at various terahertz frequencies that were displayed by metamaterials have created to accomplish a very important situation. Metamaterials are virtually desirable platforms for investigating chiral effects. In order to enhance these effects, producing the tunable chiral devices attracted lots of attention. Among the phase change materials for chiral metamaterials, graphene is a promising candidate due to its astonishing properties specifically in the THz and far infrared region.

In this study, a chiral metamaterial gammadion structure is designed and fabricated on both sides of the sapphire substrates. A commercial COMSOL and CST Microwave Studio programs are used to design and optimize the chiral metamaterial. Numerical simulations are based on the interaction of the chiral structure with linearly and circularly polarized light. In the experimental side, a resistive evaporation and dc magnetron sputtering method is used for the deposition of gold and Sb_2Se_3 films respectively. A single layer graphene is used, that is grown on a copper foil by chemical vapor deposition. The thin graphene layer transferred on the Sb_2Se_3 coated sapphire substrates. The conventional UV lithography and ion beam etching techniques are used for patterning process. The THz characterization measurements were performed in order to assess the THz frequency response and to demonstrate the dynamically tunable chiroptical response using optical pumping [3,4]. The active polarization manipulation capability of the Sb_2Se_3/graphene chiral metamaterial with frequency tunability are investigated both numerically and experimentally.

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Optimization of Large Area Thin Films for All Solid State Electrochromic Devices

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Abstract. Electrochromic (EC) device applications have already developed in the scientific and commercial field successfully but they still need improvement. Some of them are used as EC windows in buildings, aircraft and automobiles, rear-view mirror for vehicles, EC display devices, etc. [1,2]. An all-solid-state EC device consists of a multilayered structure of thin films; transparent or reflective conductor, electrochromic layer, solid electrolyte, counter electrode and transparent electrode. In this study, it is aimed to fabricate an inorganic solid-state thin-film layered dimming electrochromic rear view mirror. Liquid/gel electrolyte is used in commercially self-dimming rearview mirrors, which causes a problem of flowing over time and with the effect of hot air. When solid electrolyte is used, a more durable and stable self-dimming rear view mirror prototype will be developed. Moreover, Indium Tin Oxide (ITO) is most preferred transparent conductive electrode in commercial application. However, high cost and scarcity of Indium may limit the use of ITO in future devices. So, Zinc Tin Oxide (ZTO) / Silver (Ag) / ZTO is used as a transparent electrode in this study. As an alternative to ITO/ Ag / ITO multilayer structures, ZTO/Ag /ZTO is one of the most promising electrode choices due to its low sheet resistance below 10 ohm/sqr and high visible light transmittance of around 85% in the visible region of the electromagnetic spectrum [3,4]. Besides, ZTO contain earth-abundant and low-cost elements. In addition, Tungsten Oxide (WO3), Tantalum pentoxide (Ta2O5), Nickel Oxide (NiOx) and Aluminum (Al) films were deposited in-line magnetron sputtering system. All layers were fabricated by large-area magnetron sputtering technique and WO3 and NiOx were characterized by electrochemical technique. Ionic conductivity of Ta2O5 were measured by impedance analyzer. The optimizations of individual layers were completed and the whole structure of electrochromic layers will be discussed.

Acknowledgments

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Valence Band Electronic Structure of Azobenzene-Functionalized Gold Nanoparticles

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Abstract. Azobenzenes (Azo) represent a class of organic compounds composed of two phenyl rings linked by an N=N double bond that exhibit photoisomerization, i.e. change in conformation upon UV or visible light illumination. Photoisomerization in Azo is of high yield and reversible, which is why these molecules can act as molecular photoswitches in various biomedical and energy conversion applications. However, a broader application of Azo, particularly in biomedicine, requires lower energy of photoisomerization that falls further into visible or even NIR range. In our study, selected azobenzenes were conjugated to the surface of bare gold nanoparticles (Au NP) to obtain functional hybrid nanosystems in which photoisomerization of Azo can occur upon excitation of surface plasmon in Au NP. To understand the nature of the process, the valence band structure of Azo-functionalized Au NP was investigated by synchrotron radiation VUV aerosol photoemission spectroscopy. The results demonstrate that the overlap between the valence bands of Azo and Au NP is significant to allow for chare transfer process between the components in the nanosystem.

Gold-riboflavin hybrid nanostrucutures as possible photodynamic therapy agents

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This study reports on the optical properties of hybrid nanostructures that comprise gold nanoparticles (Au NPs) and biomolecule riboflavin (vitamin B2, Rb). The riboflavin is photosensitizing molecule and the generation of reactive oxygen species (ROS) by the hybrid nanoparticles was tested in various aqueous and biological environments. It was shown that the gold nanoparticles enhanced the photosensitizing activity of riboflavin. A comparison of EPR spectra obtained for the Au nanoparticle colloid, hybrid nanoparticle colloid and molecular water solution revealed that the strongest ROS signal came from the AuRb nanosystem. Furthermore, the ROS signal stability was much higher than that of the molecular solution, with a time span of several minutes. Photodynamic activity of the AuRb hybrids was tested by using gram-negative bacterium *Escherichia coli* as a model system. The bacteria were incubated by AuRb nanoparticles and the survival rate of the colonies was investigated by fluorescent bioimaging. The obtain results provide new insights on photosensitizer's activities and suggest advantages of using metal-based nanoplatforms for developing of novel agents for photodynamic therapies.

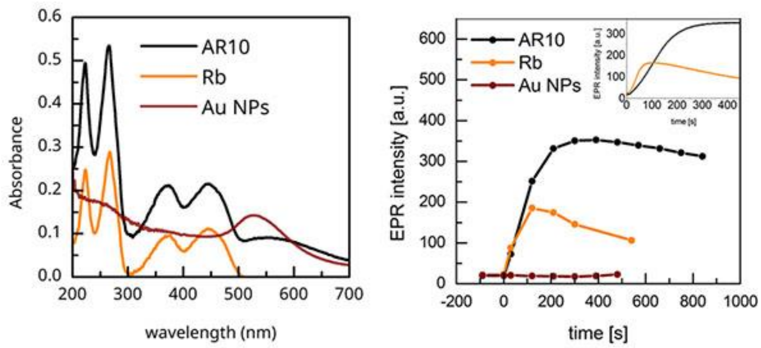

Figure 1 Absorbance spectra (left) and EPR spectra (right) of the gold nanoparticle water colloid (Au NPs), pure ribflavin water solution (Rb) and the gold-riboflavin hybrid nanoparticle colloid (AR10)

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Beam modification during propagation through aqueous microalgae suspension of interest to waveguiding

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Abstract. *Chlorella sorokiniana* Shih. et Krauss [1], due to its highest resistivity to heat and high light intensity among all *Chlorella* species [2], is a good candidate in the applications of light generation, waveguiding and modulation. Relative refractive index with respect to water is makes the cells the positive polarizability particles and lowest absorption in the green region of the visible spectrum [3] reduces the thermal effects generated from the propagating high power laser beam.

During laser beam propagation through aqueous suspensions of metal nanoparticles or microscopic marine bacteria, nonlinear effects, like thermo-optical, scattering, optical gradient forces take place in shaping the beam [4, 5]. However, strong thermal absorption of metal and sensitivity to strong light of cells limit the range of beam power. We examined the propagation of the 532 nm CW laser beam of various powers through the suspension of freshwater green microalga *C. sorokiniana* of various concentrations, placed in a glass vessel. For two concentrations of algae (0.5×10^7 cm^{-3} and 1×10^7 cm^{-3}) and several selected values of beam power (2-4 W) the beam experiences self-guiding and changes in exit cross section [6]. In this work, we pay attention to broader range of powers (0.1-5 W) and concentrations and investigate the diameter change during propagation and the cross-section change at exit wall of the vessel due to nonlinear effects, which might be interesting for waveguiding and optimal laser propagation in biological suspensions.

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Long term stability of graphene/c-Si Schottky-junction solar cells

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Abstract. Long operational lifetime is required for solar cell use in real-life photovoltaic applications. Optimization of operational lifetimes is reached through the understanding of inherent degradation phenomena in solar cells. In this study, the graphene/Si Schottky junction solar cells using liquid phase exfoliated graphene as an active surface are produced. The operational and interface stability of these solar cells over a period of 5 years in ambient conditions (ISOS-D protocols: dark-storage/shelf-life), and examine the origin of their degradation is reported. It was found that the dominant degradation mechanism could be degradation of silver contacts, which is indicated by a decrease in shunt resistance, an increase in the ideality factor (due to higher carrier recombination) and constant defect density in graphene films up to 4 years. Neither significant spatial inhomogeneity nor shunt channel defects were revealed by measurements across the solar cell active area during the 5 year period.

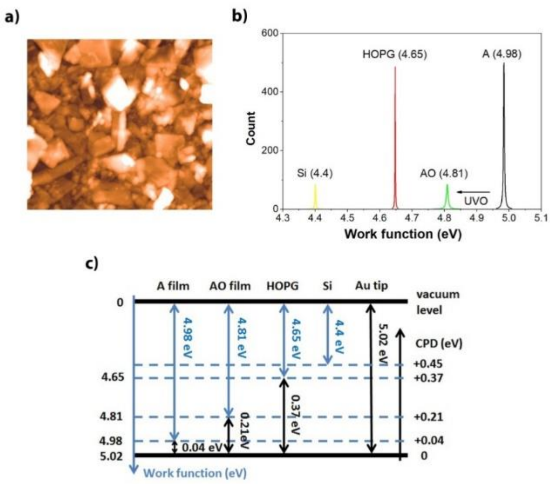

Fig.1 a) AFM (3x3 µm2, z scale 100nm),b) KPFM histograms and c) schematic of the relation between measured CPDs and their corresponding Work functions for pristine A and AO graphene films on Si/SiO_2 substrates.

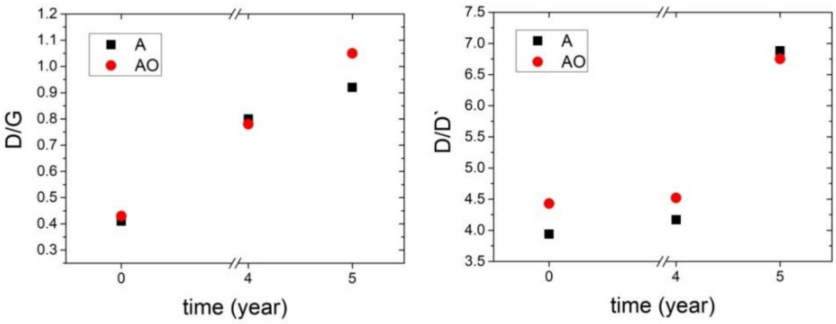

Fig. 2: D/G and D/D` ratios in time for A and AO graphene films

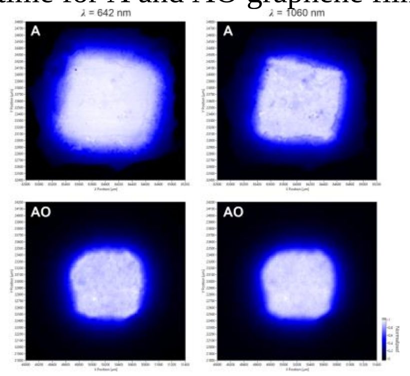

Fig.3. LBIC spatial maps of A and AO solar cells, 4 years old induced measured by 642 and 1060 nm laser wavelength.

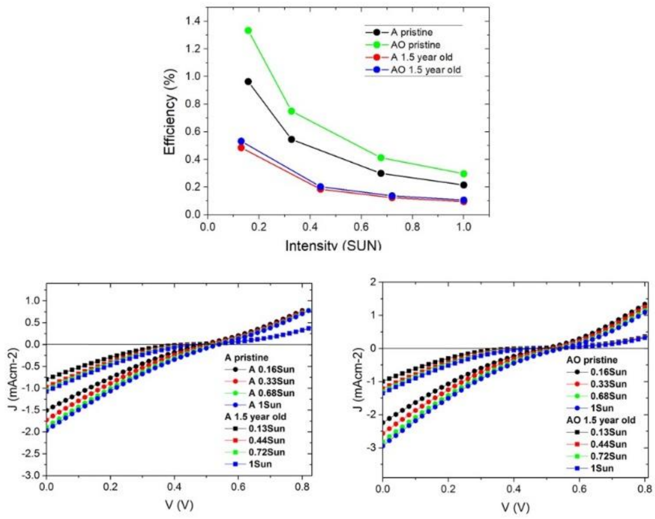

Fig. 4. Eff. and I-V light (0.1-1Sun) for A and AO pristine and 1.5 year old solar cells.

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Quantum Simulation and Computation with Neutral Atoms

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Abstract. The last few years have seen a remarkable development in our ability to control many neutral atoms individually, and induce controlled interactions between them on demand. This progress ushers in a new era where one can create highly entangled states, or study quantum phase transitions. I will present results on atomic arrays containing more than 250 atoms, including transport of entangled states, and the generation of topological surface- and toric-code states. Finally, I will discuss prospects for near- and medium-term quantum computers with full quantum error correction.

Joint event: Free Alignment precession optically pumped magnetometer

A compact pump-probe optically pumped magnetometer system

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We present a compact pump-probe optically pumped magnetometer (OPM) system for the use within the geomagnetic field range. The sensor head integrates a pump-probe scheme of a room-temperature spherical paraffin-coated cesium (Cs) vapor cell [1]. We probe changes in the circular dichroism of the Cs vapor induced by the external magnetic field of interest using an additional resonant rf magnetic field. The signal of the balanced polarimeter is read out by a phase-locked-loop implemented on a compact high-performance commercial FPGA data acquisition board [2]. Furthermore, the system features a compact single frequency distributed Bragg reflection (DBR) laser diode which is actively stabilized onto the F=4 to F'=3 hyperfine transition of the Cs D1 line (at 894.6nm).

We detail on the implementation, show sensor characterization measurements within magnetically shielded environment, and discuss further steps required towards deployment for in-field geophysical application scenarios.

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Acknowledgements

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Response of a scalar M_x magnetometer to modulation the of transverse magnetic field

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Abstract. We present our work on behavior of a M_x variant of OPM (Optically Pumped Magnetometer) [1] under modulation of the transverse magnetic field. Set-up is based on a single beam double-resonance scalar magnetometer with spherical Cs paraffin coated cell, operating in free running mode at room temperature. The medium is pumped at D_1 line at F_g=4 → F_e=3 transition with circularly polarized light, where direction of light is parallel to the oscillating magnetic field that is driving the magnetic resonance at Larmor frequency, Fig. 1. We have studied the response of our magnetometer to the changes in applied magnetic field, perpendicular to the main offset field. Set of Helmholtz coils is used for the generation of additional modulating filed. Using lock-in detection we obtained in-phase and quadrature components of the transmitted laser power oscillations. Specially, with the main offset field in z-direction, and applied modulation in yz plane, phase of the signal experience unexpected behavior for a scalar magnetometer.

We will present our measurements results and discuss which conditions, with respect to amplitude and frequency of modulating field, so as its orientation, give rise to the before mentioned signal abnormalities.

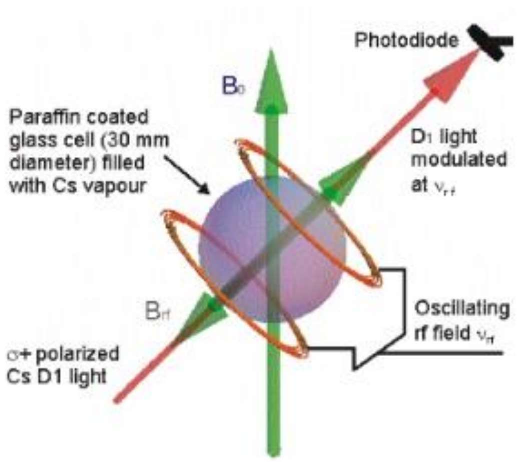

Figure 1. Schematic of the scalar M_x optically pumped magnetometer.

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Commercially available vertical cavity surface emitting laser affordable VCSEL diode laser for low noise spectroscopy of cesium D_1 line

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Abstract. This study tests the applicability of the commercially available VCSEL Laser diodes from Throlabs (part number L895VH1) for laser spectroscopy of cesium D1 line. This 895 nm, 0.2 mW AlGaAs VCSEL diode is a compact light source suited for a variety of applications. It comes in a TO-46 package with an H pin configuration. It outputs a circular Gaussian beam, which is linearly polarized. Its spectral profile is single mode and it is suitable for single frequency applications [1]. It also has such a property that may provide a simple way of making a fast-swept source by temperature tuning [2].

The laser diode in experiments is mounted inside a high thermal mass aluminum block with an NTC temperature sensor in close proximity to the laser diode and a Peltier element below the aluminum mount connecting it with a larger aluminum plate. A self-made laser driver controls the laser current via a potentiometer allowing currents from 0 mA up to 2 mA. The temperature of the diode is controlled by a NTC connected to a PID which controls a Peltier element. The laser characterization produced the following results: lasing threshold: approximately 0.6 mA and weakly divergent beam. To access the performance of the Thorlabs diode two experiments were performed and compared: with Thorlabs diode and Toptica ECDL laser system. Interestingly the PLL signal of the Toptica measurement looks nosier that the signal of the Thorlabs diode. Above 500 Hz the VECSEL diode showed a better performance than the ECDL. Measurements also show that it is possible to use the diode for FSP measurements in a two-beam approach. For this measurement, the pumping diode has not been frequency locked; meanwhile the probing diode has to be on resonance during the probing phase. Running in continuous-wave mode, the second laser could be replaced by a simple laser diode with frequency stabilization.

The mentioned laser diode is affordable, and in addition offers the possibility of conducting experiments in in the frame of the Free Alignment Precession optically pumped magnetometer project (FRAPOPM). $F=4 \rightarrow F'=3$

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Optically pumped magnetometer aiming for highest accuracy

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Abstract. Today, the demand for magnetometers with highest resolution is driven by applications relying on the detection of tiny magnetic field changes, typically in the pT down to the fT range, as encountered in biomagnetism [1], geophysics [2], or in fundamental physics experiments [3]. In addition to sensor resolution and noise level, properties like accuracy and rotational invariance of the measurement are vital in scenarios where the sensor has to be applied from mobile platforms such as in geophysical exploration methods [2]. While optically pumped magnetometers (OPMs) [4] are based on a principle which enables them to yield scalar and absolute measurements of the magnetic field, they do suffer from systematic effects which may exceed their intrinsic sensitivity limit, thus severely compromising their performance especially in mobile applications.

I am going to present the concept and first experimental results of a novel OPM measurement technique called free alignment precession. Sensors based on this technique will offer highest sensitivity combined with unprecedented accuracy by strongly reducing systematic effects inherent to other state-of-the-art OPMs [5].

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Acknowledgements

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Functionalization of microfabricated cesium vapor cells for optically pumped magnetometers

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Abstract. Optically pumped magnetometers (OPMs) emerge as powerful sensors for a number of important applications such as in geophysics, biomedicine, fundamental physics and more. In contrast to other ultra-sensitive magnetometers like superconducting quantum interference devices (SQUIDs), they operate at room temperature and above [1], whereby complex cryogenic cooling systems become obsolete. The main component of OPMs are alkali vapor cells which can be microfabricated [2]. The implementation of specific functionalization of these cells can be performed in order e.g. to influence light propagation, to control the thermal regime and to increase the durability of the cells [3]. Our group has already established a wafer-based fabrication process of cesium vapor cells for various applications including specific functionalization. In my presentation I will introduce these processes on selected cell designs, discuss crucial steps, and detail on challenging parameters. More specifically, I will provide insights on integrated optical mirrors, anti-reflection coatings, resistive layers for electrical heating and methods to passivate the inner cell walls. Furthermore, concepts for future developments will be discussed.

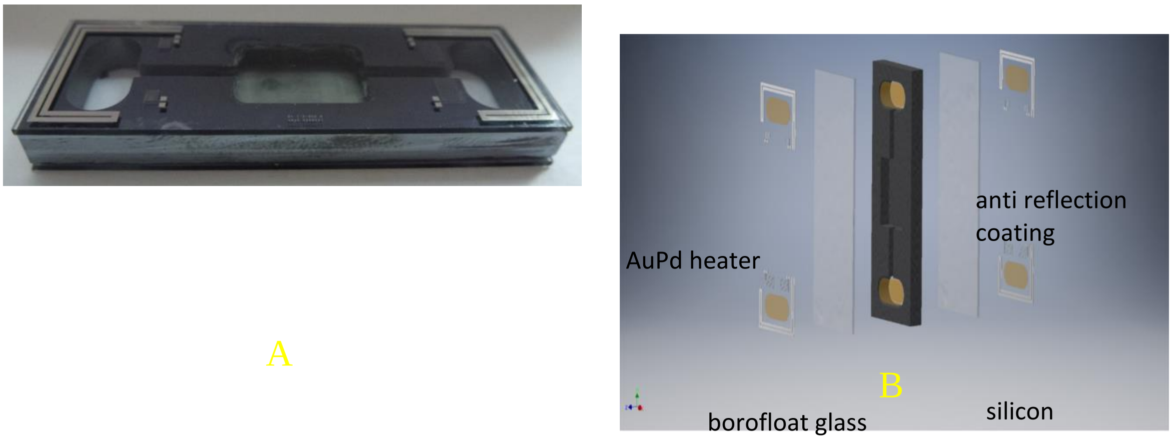

Figure 1. (A) Picture of a cesium vapor cell array enhanced with anti-reflection coatings and heating circuitry, (B) explosion view with highlighted details.

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Frequency Estimating Device for Optically Pumped Magnetometer

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Abstract. For high precision measurement of magnetic field at high rate with Optically Pumped Magnetometer (OPM) device for frequency estimating is used. This device beside acquisition of sinusoidal exponentially decaying signal also need to process samples with algorithm, such as least-squares curve fitting [1], to estimate Larmor frequency ω_L (or $2\omega_L$) which is proportional to magnetic field. Architecture of frequency estimating device is shown Fig. 1. For acquisition of OPM output electrical signal with duration up to 100 ms is done with 3 MSPS 18-bit Analog-Digital Converter (ADC) with digitized samples being sent to Field Programmable Gate Array (FPGA) from Zynq family [2]. Samples are stored to DDR memory and later are processed by ARM CPU and Coprocessor in FPGA fabric. FPGA boots its software with frequency estimation algorithm from SD Card and results are sent to Personal Computer (PC).

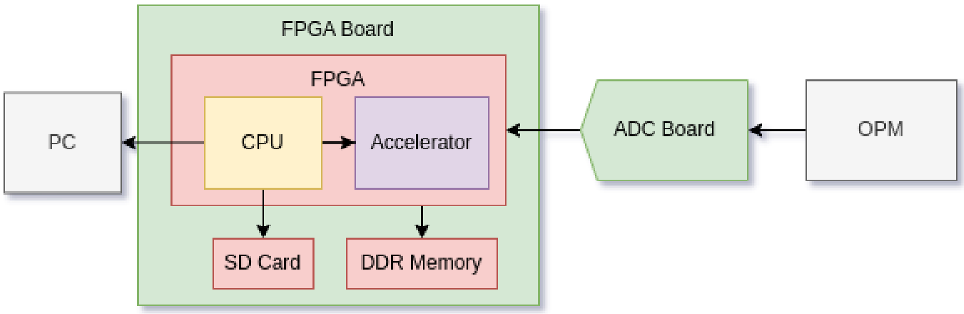

Figure 1. Architecture of measurement device.

Algorithm is first implemented using off-the-shelf least-squares curve fitting library in Julia language and run on PC with synthetic and measured signals. Duration of single estimation is 4 s. To make this estimation running below needed 100 ms, appropriate acceleration is needed by parallelisation. Code is further profiled to expose most demanding parts which will be accelerated. That code is then simplified and transcribed in C++ language, which could be compiled on PC and for ARM on FPGA. Accelerator is implement in FPGA fabric as double precision floating point SIMD processor with simplified instruction set. While the most algorithm is run on ARM CPU, the most demanding parts of algorithm are implemented in assembly language and run on accelerator processor. Such partitioning approach gives flexibility to easily change existing algorithm or faster implementing new algorithm. Prototype of device is implemented on ZedBoard FPGA board with accelerator working at 190 MHz with single estimation around 400 ms, which is limited by size and speed of FPGA. Further step is obtaining Zynq Ultrascale family FPGA board from Trenz, which will enable needed 100 ms estimation time.

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Heading error of Free Alignment Precession optically pumped magnetometer

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Abstract. While optically pumped magnetometers (OPMs) have demonstrated competitive sensitivities and low cost with respect to competition, their performance for high accuracy applications is not well studied. Our first attempt [1] to optimize an all optical free spin precession (FSP) magnetometer was success. In unpublished investigations that followed that work it was discovered that FSP magnetometer suffers from a heading error two orders of magnitude larger than its sensitivity. In order to improve the performance a method that uses linearly polarized light Free Alignment Precession (FAP) was proposed.

In this study we measure the Larmor frequency, in a spherical cesium cell with antirelaxation coating, simultaneously with two linearly polarized beams. The experimental setup allows arbitrary mutual orientations of magnetic field $B_0 \approx 1.58$ µT and directions of polarizations of light beams.

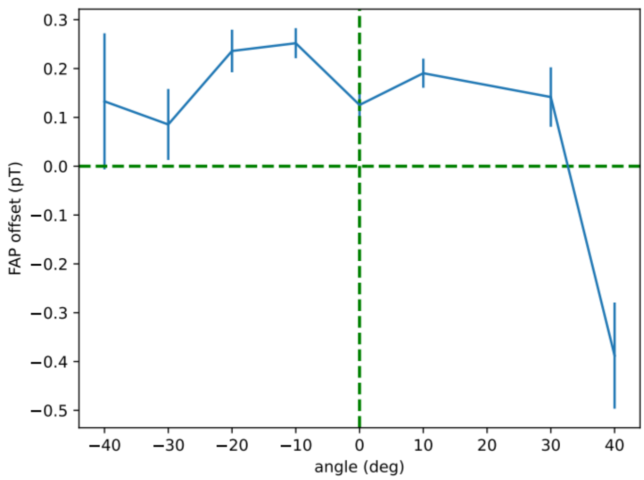

Figure 1. Preliminary measurement of the heading error of a FAP magnetometer. Direction of the B_0 and polarization direction of one of probe beams was fixed while we varied the polarization direction of the second probe beam.

From Fig. 1. we learn that, in this particular case, the heading error is below 1 pT, thus at least six orders of magnitude below B_0. Further investigation is under way.

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Analysis of the dynamic RF projection phase in True Scalar Cs Magnetometers

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Abstract. A true scalar magnetometer (TSM) is one where the phase is independent of the magnetic field orientation and instead depends on the modulus only. We analyzed a magnetometer consisting of a paraffin-coated glass cell filled with CS vapor where the RF field is parallel to the light propagation direction while oscillating at Larmor frequency [1]

The magnetometer was applied in the measurement of small magnetic field components orthogonal to the main field direction. Experimental measurements of the RF projection phase show significantly different behavior in cases where the transversal field component is perpendicular to the RF field and when it is in the plane formed by the main magnetic and the RF fields. For the "in-plane" case the RF projection phase doesn't show any perturbation on changing the intensity or field direction, while the "perpendicular" case shows significant peaks and slow relaxations under the same circumstances.

This phenomenon was initially explored through numerical simulations with a model that shows good agreement with experimental results and later backed with analytical calculations of the Bloch equation for this case in Cartesian spin components. The equations were solved analytically by moving into a rotating frame of reference and applying the Rotating Wave Approximation (RWA) and the disambiguation of the remaining solution terms by the significance of their contribution. The results show a simplified picture of the described problem but capture the qualitative behavior well. The measurements, numerical solution and the analytical approach will all be presented in a wholesome description and analysis of the described phenomenon.

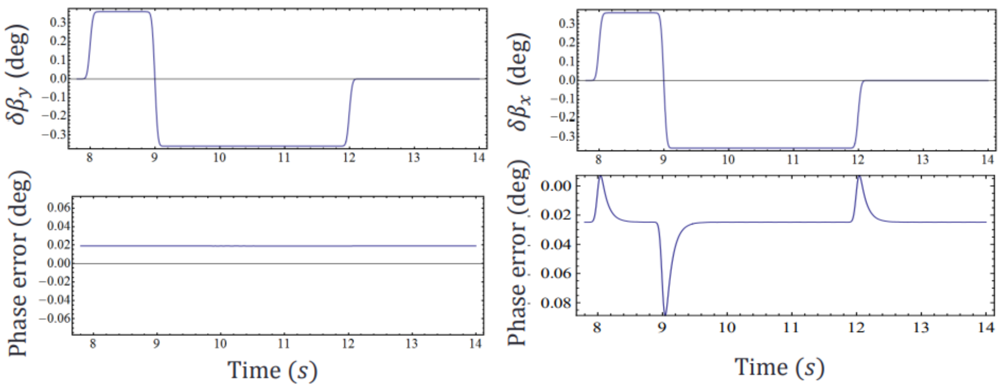

Figure 1. Two different field geometries considered for the DC transverse magnetic field scans. Left: The "in-plane" case with constant phase error, Right: The "perpendicular" case with phase error perturbations.

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