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(Conference)

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Conference program

Monday, March 15th

Chairman: Branislav Jelenković

16.30 - 17.00	**Srdjan Antic** *Genetically-Encoded Calcium Indicator (GECI) versus a Genetically-Encoded Voltage Indicator (GEVI)*
17.00 - 17.30	**Tanja Dučić** *Correlative synchrotron based spectro-microscopy techniques for elucidation cellular disorders in ALS*
17.30 – 17.45	Coffee break
17.45 – 18.05	**Mirbek Turduev** *Optimization based bi-directional optical cloaking design*
18.05 – 18.20	**Jelena Mitrić** *Surface Optical Phonon in Europium doped Yttrium Orthovanadate Nanopowders*

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20.00 - 20.20	**Veljko Zarubica** *Metrological observation spectrophotometric standard referent materials SRM*
20.20 - 20.40	**Duška Popović** *Partial-wave analysis of the resonantly enhanced multiphoton ionization of sodium by femtosecond laser pulses*
20.40 - 20.55	**Saša Topić** *Applications of astrophotonics: Diffraction limited single mode PCF Echelle spectrograph for Exoplanetology, Astroseismology and cv studies*
20.55 - 21.10	**Saša Topić** *Search for ultralight bosonic ALP dark matter in form of topological defects: design, calibration, sensitivities of Belgrade GNOME station*
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Tuesday, March 16th

Chairman: Pavle Andjus

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17.00 - 17.30	**Milan Radonjic** *Non-equilibrium evolution of Bose-Einstein condensate deformation in temporally controlled weak disorder*
17.30 – 17.45	Coffee break
17.45 – 18.05	**Zoran Grujić** *Applications of optically pumped magnetometers*
18.05 – 18.20	**Yasemin Demirhan** *Optical Emission Spectroscopy of Large Area Roll-To-Roll Sputtered ITO Thin Films for Photovoltaic Applications*

Chairman: Bratislav Marinković

20.00 - 20.20	**Branislav Jelenković** *Non-invasive optical methods for detecting neuronal signals*
20.20 - 20.40	**Dušan Arsenović** *Influence of Doppler effect on pulse shapes in FWM*
20.40 - 20.55	**Marija Ćurčić** *Generation of quantum correlated beams by Four Wave Mixing in Potassium vapor*
20.55 - 21.10	**Dragutin Šević** *Host effects on luminescent properties of Er,Yb doped nanophosphors*
21.10 – 21.25	**Dragan Lukić** *Atomic line referenced Mach Zehnder Interferometer calibrators for reaching extreme precision radial velocities in Dopler spectroscopy*
21.25 – 21.40	**Aleksander Kovačević** *Laser-induced parallel structures on multilayer thin films of Ni, Pd, Ti, Ta and W*

Wednesday, March 17th

Chairman: Zoran Grujić

16.30 - 17.00	**Marco Canepari** *Optical measurement of neuronal Ca2+ and Na+ currents in the native system*
17.00 - 17.30	**Nikola Stojanovic** *Femtosecond laser spectroscopy for Exploration of Space: Introduction of new research group at German Aerospace Center*
17.30 – 17.45	Coffee break
17.45 – 18.05	**Pavle Andjus** *SEM imaging of astrocytes exposed to ALS immunoglobulins*
18.05 – 18.20	**Denis Abramović** *Single-photon holography*

Chairman: Marina Lekić

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20.20 - 20.40	**Đorđe Jovanović** *Is solar going indoors?*
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21.25 – 21.45	**Dejan Pantelić** *Real time fabrication of microlens arrays for security applications*

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Abstracts

Non-invasive optical methods for detecting neuronal signals

Branislav Jelenković

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

Abstract. An important issue in neuroscience is unveiling and understanding the limits of signal detection in biological systems. A great deal of effort is committed to elucidating limits of detection in vision, which have not been directly measured yet due to the significant deficit in available technology. Studying vision in insects and mammals most often involves measuring electric potentials induced by photons in retinal photoreceptors, using classical light sources for illumination and invasive patch clamp method for detection. Quantum optics provides methods for which neuroscientists have hoped for a long time - source of non-classical light and noninvasive quantum detector of action potential in neurons.

Heralded and entangled photons have already played role in investigating vision in vertebrates [1] and were essential in the protocol used to demonstrate detection of a single photon by a humane eye [2]. The setup for generating pairs of heralded photons, based on available lasers in our laboratory, will be presented. I will present principles of the ultra-sensitive magnetometer based on quantum defects in the nitrogen vacancy centers (NV) in diamonds, used already for noninvasive measurements of biological electrophysiological signals in neuron in vertebrates [3],

I will discuss planed experiment, with above tools from quantum optics, for detecting ommatidial signals after photon absorption, and determining absolute limit of the photon sensitivity detection in ommatidia from the common fruit fly *Drosophila*.

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Genetically-Encoded Calcium Indicator (GECI) versus a Genetically-Encoded Voltage Indicator (GEVI)

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Abstract. Genetically-encoded calcium indicators (GECIs) are essential for studying brain function, while voltage indicators (GEVIs) are only slowly permeating the systems neuroscience. Fundamentally, GECI and GEVI measure different things, but both are advertised as reporters of “neuronal activity”. We quantified the similarities and differences between calcium and voltage imaging modalities, in the context of population activity in brain slices. Population signals are measurements of compound neuronal activity without single-cell resolution. Population imaging is rapidly gaining in popularity, because: [a] one can record from several brain regions at the same time, [b] many animals with embedded fluorescent indicators are commercially available, and [c] equipment is affordable. In our hands, the GECI optical signals showed 8 - 20 times better SNR than the GEVI signals, but GECI signals attenuated more with distance from the stimulation site. We show the exact temporal discrepancy between calcium and voltage imaging modalities, and discuss the misleading aspects of GECI imaging. For example, population voltage signals already repolarized to the baseline (~disappeared), while the population calcium signals were still near maximum. The region-to-region propagation latencies, easily captured by GEVI imaging, are blurred in GECI imaging. Temporal summation of GECI signals is highly exaggerated, causing uniform voltage events produced by neuronal populations to appear with highly variable amplitudes in GECI population traces. Relative signal amplitudes in GECI recordings are thus misleading. In simultaneous recordings from multiple sites, the compound EPSP signals in cortical neuropil (population signals) are less distorted by GEVIs than by GECIs. Supported by: *National Institute on Aging* & *The Cure Alzheimer’s Fund*.

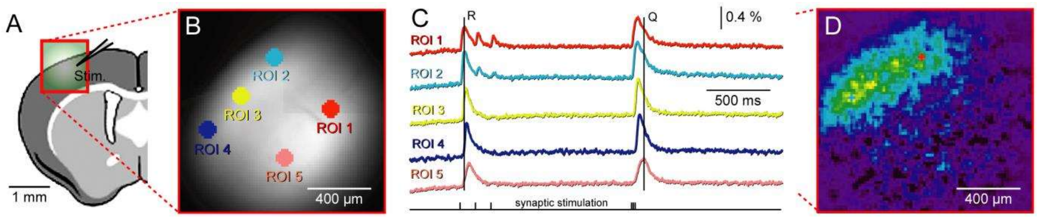

Figure 1. Voltage imaging of synaptically-evoked neuronal depolarizations. (**A**) Coronal section through mouse brain with position of synaptic stimulation electrode inside cerebral cortex. Scale, 1 mm. (**B**) A fluorescence microphotograph of a brain section of transgenic animal expressing a fluorescent voltage inadicator protein in pyramidal neurons. Surface of brain slice with 5 regions of interest (ROIs) selected for spatial averaging. (**C**) The black trace at the bottom marks the timing of two triplets of synaptic shocks, with 120 ms interspike interval (first), and with 12 ms interspike interval (second triplet). Vertical line R marks the peak of voltage depolarization in ROI-1. Vertical line Q marks the peak of voltage depolarization in ROI-5. (D) Same area as in B, excpet optical signals amplitudes are coded by color, where dark purple is the minimum and bright red is the maximum of the optical signal amplitude. Overall, this figure shows that spatial and temporal spects of a biological response (i.e. synaptically-evoked depolarization) were succesfully recorded using the GEVI imaging methodology.

Laser-induced parallel structures on multilayer thin films of Ni, Pd, Ti, Ta and W

Aleksander G. Kovačević[1], Suzana Petrović[2], Jelena Potočnik[2], Marina Lekić[1], Branislav Salatić[1], Vladimir Lazović[1], Dejan Pantelić[1], Branislav Jelenković[1]

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Abstract. The interaction of ultrashort laser beam with metal surfaces may induce the generation of periodic structures (LIPSS) with period less than the incoming wavelength, opening wide area of application [1, 2]. The presence of the underneath layer influences the quality of the LIPSS [3] . We have exposed multilayer thin films Ni/Ti, Ni/Pd, W/Ti, Ti/Ta to femtosecond beams of various wavelengths and powers. The interactions have been performed by Mira900 fs laser of Coherent. Detailed surface morphology after irradiation was examined firstly by optical microscopy, and then by scanning electron microscopy (JEOL JSM-7500F, Tokyo, Japan). Two types of structures have been noticed. Their appearance differ in the direction against the polarization direction, in pronounced ablation and in the spatial period, enabling their grouping into LIPSS of higher and lower spatial frequencies. Surface plasmon polariton is seen as the most probable cause of periodic distribution of energy at the surface and consequently to LIPSS.

Acknowledgements. The work was supported by the Ministry of Science of the Republic of Serbia under No. III45016 and OI171038. The authors also thank dr Davor Peruško from the Institute of Nuclear Sciences "Vinča" (University of Belgrade), dr V. Pavlović from the Faculty of Agriculture (University of Belgrade), dr Đ. Veljović and dr Ž. Radovanović from the Faculty of Technology and Metallurgy (University of Belgrade) and dr A. Krmpot and dr M. Rabasović from the Institute of Physics (University of Belgrade), for their valuable support.

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Quantum-state tomography with room-temperature atomic vapor

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Abstract.

Quantum information processing requires three crucial elements: the ability to store and retrieve quantum information, the ability to controllably modified the information, and the ability to reliability store the information (immunity against noise). Realization of these tasks requires development of efficient techniques of quantum-state tomography.

A particular medium enabling storage and processing of quantum information are room-temperature atomic vapors. Such media contain a huge number of atoms, so that the atoms can be only described effectively, using a collective density matrix. Yet, under specific conditions (e.g., in atmosphere of high-pressure noble gas or inside a special container) all atoms in the vapors may be considered to reside in an identical (internal) quantum state and manipulations can be viewed as performed at all atoms in the same manner. At the same time, the huge number of atoms open means for weak continuous measurements. Such weakly perturbing measurements provides small amount of information when used to a single atom, but the ability to interact with all atoms allows to retrieve rich information about the system.

In our talk we will present the ability to reconstruct a collective quantum state of rubidium vapor residing in a long-lived ground state. We will demonstrate that detection of polarization rotation induced by atoms subjected to the longitudinal magnetic field provides access to specific density-matrix elements. We will also show that application of magnetic-field pulse prior to the detection, gives access to different density-matrix elements. Due to presence of noise and uncertainty in experimental conditions, this approach may lead to reconstruction of an unphysical matrix. Therefore, we will show the means of estimating a real density matrix using the obtained results. The considerations will be performed both for pure and mixed states and the fidelity, characterizing precision of reconstruction, will be tested against such parameters as noise, number of measurements, and state purity.

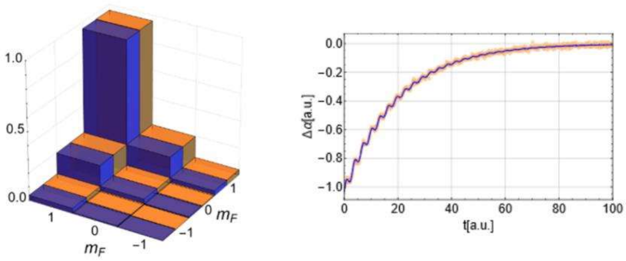

Figure 1. Initial (blue) and reconstructed (orange) amplitudes of density-matrix elements (left) and exemplary rotation signal (right) measured for an exemplary density matrix.

Influence of Doppler effect on pulse shapes in FWM

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Abstract. Four-wave mixing (FWM) is a complex nonlinear phenomena which may be present in atom vapors. Here we theoretically analyze pulse propagation of strong pump, weak probe and conjugate beams in potassium vapor. Involved atomic levels form a non-resonant double Λ configuration. We solve Maxwell-Bloch equations by numerical simulations. They incorporate atom-field interactions as well as spontaneous emission and relaxation effects. Also Doppler is taken into account by calculating density matrices for group of atoms moving with different velocities. Here we analyze the influence of Doppler averaging on the numerical results as well as compare them with the experimental results. Doppler averaging is characterized by the number of atom groups, homogeneous or non-homogeneous distribution of their velocities and the interval of these velocities. Probe is a 80 ns pulse which together with continuous wave pump enters a potassium vapor at 120 C with one-photon detuning in the 0.7 – 1 GHz range.

Non-equilibrium evolution of Bose-Einstein condensate deformation in temporally controlled weak disorder

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Abstract. In this talk we are going to consider a time-dependent extension of a perturbative mean-field approach to the homogeneous dirty boson problem by considering how switching on and off a weak disorder potential affects the stationary state of an initially equilibrated Bose-Einstein condensate by the emergence of a disorder-induced condensate deformation. We will show that in the switch on scenario the stationary condensate deformation turns out to be a sum of an equilibrium part [1], that actually corresponds to adiabatic switching on the disorder, and a dynamically-induced part, where the latter depends on the particular driving protocol [2]. If the disorder is switched off afterwards, the resulting condensate deformation will acquire an additional dynamically-induced part in the long-time limit, while the equilibrium part will vanish. We are also going to present an appropriate generalization to inhomogeneous trapped condensates. Our results demonstrate that the condensate deformation represents an indicator of the generically non-equilibrium nature of steady states of a Bose gas in a temporally controlled weak disorder.

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Optical Emission Spectroscopy of Large Area Roll-To-Roll Sputtered ITO Thin Films for Photovoltaic Applications

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Abstract. Flexible optoelectronic devices such as organic light emitting diodes (OLED), touch-panel displays and flexible polymer solar cells etc. have been substantially growing. Since Indium-tin oxide (ITO) has exceptional operational properties namely low electrical resistivity and high transparency across the solar spectrum region with respect to other transparent conducting oxide (TCO) materials it has been extensively employed as transparent electrodes in photovoltaic (PV) instruments [1-3]. Besides, there are a few key limitations like durability of flexible transparent electrode materials, the poor adhesion and low crystalline qualities. In this study, using a large area roll-to-roll DC magnetron sputtering system deposition of ITO thin films on polyethylene terephthalate (PET) substrates were achieved. In order to investigate the effect of growth conditions on the film properties all through the deposition process, optical emission spectroscopy (OES) analysis have been accomplished in a governable way (Fig 1.).

Fig.1 The schematic of our coating system, our ITO coated PET films and OES data.

The consequences of oxygen partial pressure and film thickness on electrical, and optical properties of the films were determined. It was shown that the intensity of optical emission peaks are subjected to the discharge power and as well as the O_2/Ar flow ratio. Large area, uniform ITO films with relatively high transparency and low electrical resistivity (R_s<50 ohm/sqr) were succesfully deposited on PET substrates. The significance of both the figure of merit (FOM) and the optical band gap values on the performance of different TCO thin films were addressed. In this work, the obtained results suggest that the overall performance is sufficient to implement the ITO films in photovoltaic and OLED applications [4].

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Optimization based bi-directional optical cloaking design

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Abstract. In this manuscript, we demonstrate the design and experimental proof of an optical cloaking structure which bi-directionally conceals perfectly electric conductor (PEC) object from incident plane wave. The first ideas of concealing an object have emerged in studies based on Transformation Optics [1]. After first introduction of optical cloaking there were plenty of approaches of an optically object hidings such as carpet [2], helical and circular mantle [3], plasmonic layer coating [4], topology optimization cloaking [5]. In our study to design the bi-directional cloaking structure, 3D finite-difference time-domain method is integrated with genetic algorithm (GA). The designed structure has circular shape discretized into square elementary cells that can be either non-magnetic/all-dielectric PLA (polylactide) material or air as shown in Fig. 1(a). The states of elementary cells are meta-heuristically determined by GA, i.e., the permittivity distribution around the highly reflective scattering PEC object is optimized for directional cloaking. For optical cloaking, the scattered field at around the structure is minimized as well as optical power transmission efficiency is maximized during the optimization process as shown in Fig. 1(b) and 1(c). As a result, optimization approach suppresses the reflected light and reproduces incident wave behind the structure by reducing the fluctuations at the back plane of the structure. The proposed cloaking design is fabricated by 3D printing technique and cylindrical brass metal alloy object is selected as a highly scatterer (PEC) to be cloaked at microwaves. The working principle of optical cloaking is experimentally demonstrated at microwave frequency of 10 GHz for transverse-electric polarization of incident light.

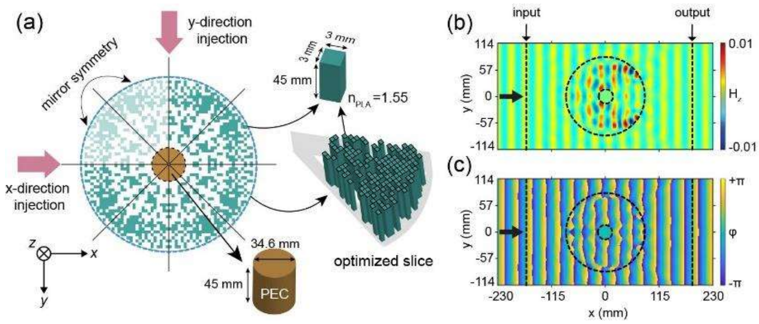

Figure 1. (a) Schematic representation and the design approach of the cloaking structure with physical dimensions of each unit cell and the PEC. The calculated magnetic (b) field and (c) phase distributions for x-direction injection.

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Database hosted photoelectron spectra and their analysis using machine learning methods: neural network approach

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Abstract. Our aim is to develop a project for a particular spectra identification where spectra are obtained either by photoelectron or electron spectroscopy methods in which recorded electron intensities are shown versus either incident photon/electron energy or kinetic energy of ejected/scattered electrons. Spectra are massively collected and curated within databases [1]. A specific database designed for the curation of such spectra is BeamDB – Belgrade Electron Atom/Molecule DataBase [2] with the example of the spectrum given in Fig.1.

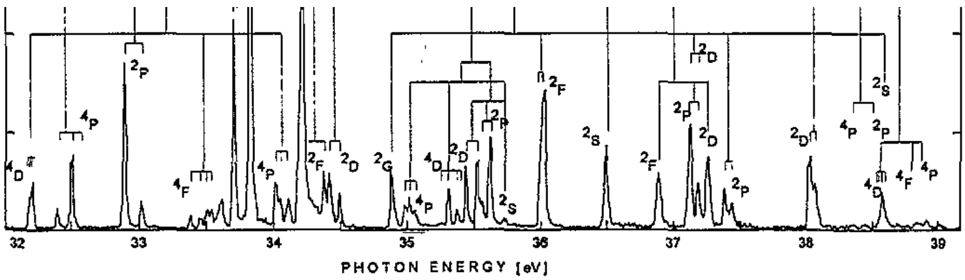

Figure 1. An example of the threshold photoelectron spectrum of argon in the 32-39 eV range [from 3] digitized and contained within BeamDB.

The analysis of spectra is based on machine learning algorithms (Artificial Neural Network- ANN) [4] and the previous knowledge on expert systems for Threshold Spectra Analysis [5] and ANN for the verification of a person using a fingerprint [6]. In our future work we will utilize a training of ANN by using the leaky rectified linear unit activation function. The difference between predicted value and actual value (error) will be propagated backwards to adjust the weights of the network. In order to employ ML algorithms we will need to enlarge the number of spectra that are contained within the BeamDB [7].

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Generation of quantum correlated beams by Four Wave Mixing in Potassium vapor

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Abstract. We will present results that demonstrate relative intensity squeezing generated by four wave mixing (FWM) in potassium vapor. Non-degenerate FWM is realized using double lamda scheme on D1 line. We will show that, for the adequate experimental parameters, the difference signal between the correlated probe and conjugate beams has a noise spectral density below the corresponding standard quantum limit (SQL).

We have varied the experimental parameters: pump and probe power, one photon (OPD) and two photon detunings (TPD), vapor temperature and cell length in search for optimal set of parameters for maximal intensity squeezing. So far, we have found the best squeezing of -7 dBm, obtained for the pump power of 850 mW, probe power of 5 uW, OPD = 1100 MHz, TPD = 8 MHz, T = 121°C, L_{cell} = 2.5 mm, and the angle between the probe and the pump of 4.5 mrad. This level of squeezing is significantly higher than the one reported in the previous study in K [1]. We will discuss how the various experimental paremeters affect the squeezing and compare the values we have measured with the published results for the other alkali elements, Rb[2] and Cs[3]. We also address the issue of finding the true squeezing in the potassium cell from measured losses of the probe and conjugate between the cell and the balanced detector, and known detection efficiency

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Partial-wave analysis of the resonantly enhanced multiphoton ionization of sodium by femtosecond laser pulses

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Abstract. We studied resonantly enhanced multiphoton ionization (REMPI) of sodium induced by femtosecond laser pulses of 800 nm wavelength in the range of laser peak intensities belonging to the over-the-barrier ionization domain. The positions of REMPI peaks in the calculated photoelectron energy spectra agree with the peak positions in the spectra obtained experimentally by Hart et al [1]. A partial wave analysis of these peaks revealed that each peak is a superposition of the contributions of photoelectrons produced by REMPI via different intermediate states. We investigated the possibility for selective resonantly enhanced multi photon ionization through a single channel and showed that it is possible to choose the main ionization channel by changing the laser intensity.

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Surface Optical Phonon in Europium doped Yttrium Orthovanadate Nanopowders

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Abstract. Semiconducting nanomaterials, especially nanophosphors have attracted great attention of researchers, due to their wide spectrum of applications in industry, technology as well as in fundamental science. When made in nanoscale, phosphor materials exibit enhanced optical properties as against their bulk counterparts, due to quantum size effects and increased surface – to – volume ratio. Yttrium orthovanadate is a widely used red phosphor with many applications in just recent years in solar cells [1], cancer treatment [2], biotechnology [3], etc.

In this paper two methods of preparation of yttrium orthovanadate nanopowder were presented: top – down approach, Solid State Reaction and bottom – up approach, Solution Combustion Synthesis. We report the change in reflection spectra in europium doped YVO_4 nanopowders with comparison to its bulk analog. In UV – Vis reflection spectra we consider the change in values of band gap in these structures, after resizing it from bulk to nanomaterial. We show the existence of Surface Optical Phonon (SOP) and different phonon processes which alter the reflection spectra of bulk YVO_4. Reflection IR spectra were modeled using classical oscillator model with Drude part added which takes into account the free carrier contribution. Since our materials are distinctively inhomogeneous materials, we use Effective Medium theory in Maxwell Garnett approximation to model its effective dieletric function. For full structural characterization, X – Ray Powder Diffraction and Field Emission Scanning Electron Microscopy were used.

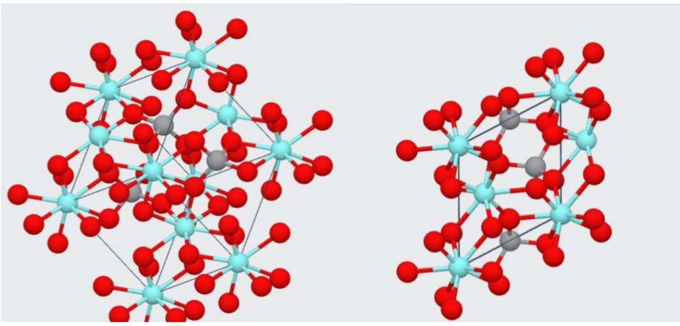

Figure 1. Crystal structure of yttrium orthovanadate

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Metrological observation spectrophotometric standard referent materials SRM

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Abstract: Spectrophotometric solutions and filters-wavelength standards used for wavelength absorption spectrophotometers calibration, used in absorption spectrophotometry (i.e. calibration of the wavelength scale of the before mentioned instruments) are subject of this paper. Metrologically characterized materials, which are mostly used as wavelength standards in absorption spectrometers calibration processes are presented and analysed during ten years. The term "metrologically characterized materials" represent equivalent of the materials, which precisely define spectral coefficients of transmittance (e.g. absorption), as well as determined influencing parameters which may appear, thus contributing to the uncertainty of the measurement. The aim of the paper was comparison of measurements made ten years ago and today, in order to track changes of standard during this time.

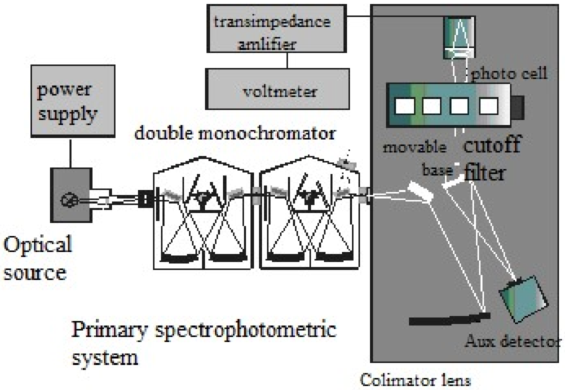

Fig.3.Optical setup of a spectrophotometric system for standard of spectral coefficient of transmittance.

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Host effects on luminescent properties of Er,Yb doped nanophosphors

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Abstract. In this study we analyze nano powders Gd_2O_3, $CaGdAlO_4$, Y_2O_3S and $YAlO_3$, doped with Er^{3+} and Yb^{3+}. Our aim was to examine effects of host matrices on optical emission of erbium. For this purpose the luminescence spectra of all samples were obtained in a continuous series of measurements under the same experimental conditions. Our experimental setup is presented in detail in [1,2]. Materials were excited at 980 nm by using pulsed laser diode. Moreover, the samples were prepared in the same way, by combustion synthesis [3]. We compare the possibilities of using these materials for remote temperature sensing. Intensity ratios of spectral lines were used for determining the calibration curves for remote temperature sensing [4-6]. Luminescence intensity ratios (LIR) were determined in a range from 300 K up to 660 K.

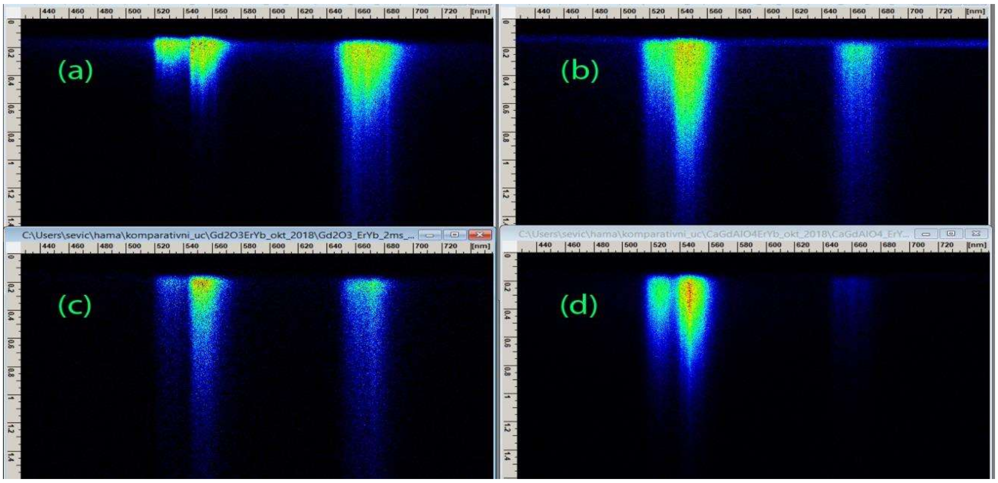

Figure 1. Streak images of (a) Y_2O_3S:Er,Yb, (b) $YAlO_3$:Er,Yb (c) Gd_2O_3:Er,Yb (d) $CaGdAlO_4$:Er,Yb.

Our analysis shows that all synthesized materials are suitable for temperature measurements. In our future work we will analyze prospects of using the erbium optical emission lifetime for temperature sensing.

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Correlative synchrotron based spectro-microscopy techniques for elucidation cellular disorders in ALS

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Abstract. Generally, molecular neuroscience is in requirement of new techniques that would broaden the set of tools available for elucidation and investigation of known and to be discovered disease features [1]. Here we present a correlative approach of several synchrotron based imaging and spectroscopy techniques for analyzing cellular composition and disorders in Amyotrophic lateral sclerosis (ALS). One of familial ALS cases is caused by mutations in the metallo-enzyme copper-zinc superoxide dismutase (SOD1). In this study, we employed multimodal synchrotron radiation based spectro-microscopies *in situ*, to investigate the astrocytes of the rat hSOD1 G93A rat ALS model that overexpresses human mutated SOD1. We analyzed protein aggregates and the alterations in the cellular ultrastructure, and elemental and the organic composition of the astrocytes isolated from the G93A model rat. Particularly, these methods do not require different or offensive cellular preparation. Our results demonstrate that large aggregates in the form of multivesicular inclusions form exclusively in the ALS model astrocytes. Moreover, the cellular copper concentration and the amount of anti-parallel β-sheet structures were significantly changed within the cells of the ALS model. We show that ALS cells contained more Cu, which co-localized with total lipids, increased carbonyl groups and oxidized lipids, thus implying direct involvement of Cu in oxidative stress of lipidic components without direct connection to protein aggregation in situ [2, 3]. This multivariate approach, by employing several correlative spectro-microscopical methods, could be used for imaging of other specimens and we believe it has the potential to become an important tool for a more comprehensive understanding of neurodegenerative disease progression at the sub-cellular level.

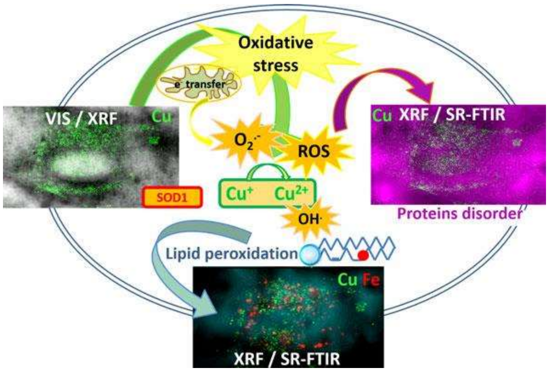

Figure 1. Sheme of simultaneous use of synchrotron - based methods: Fourier transform infrared micro-spectroscopy (SR-FTIR) and hard X-ray fluorescence microscopy (XRF) [3].

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SEM imaging of astrocytes exposed to ALS immunoglobulins

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Abstract. Amyotrophic lateral sclerosis (ALS) is a fatal neurological disorder affecting upper and lower motoneurons. It is also known that the glial cells are affected and contribute to the non-cell autonomous mechanism of the disease. Immunoglobulins G (IgGs) from patient plasma are considered to be humoral factors of neuroinflammation in this disease. We have shown in a number of previous studies that ALS IgGs may affect the physiology of glial cells in culture, particularly Ca^{2+} homeostasis, intracellular vesicle mobility and free radicals balance.

In this study we aimed to reveal by SEM morphological changes of rat astroglial cells that were previously exposed to ALS IgGs. As controls we used astrocytes that were exposed to healthy subjects IgGs and intact astrocytes. After 20 min in IgG, the monolayer of cultured astrocytes was washed with PBS and fixed in 2% glutaraldehide. 2% paraformaldehide in PBS. The sample was post-fixed in OsO_4, washed and dehydrated in a series of ethanol solutions and left in a drying chamber. Dried samples were mounted on an Al base and coated with a gold. Imaging was performed on an SEM JEOL JSM-6390 LV instrument.

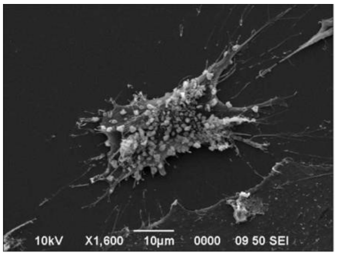

Figure 1. SEM of a fixed astrocyte in culture

The images were analysed for fractal dimension (FD) and lacunarity and for texture using the grey-level co-occurrence matrix method. Astrocytes treated with ALS IgGs had a higher FD compared to both controls which was congruent with a significantly lower lacunarity. The texture analysis revealed also some difference between both IgG treatments and intact cells but also revealed significant differences between two IgG treatments (higher values in ALS IgGs for Entropy and Variance and smaller for Angular second moment, Inverse Difference Moment, Homogeneity, Prominence, and Correlation).

We have thus shown that the physiological actions of ALS IgGs have a repercussion on the morphology and organizational complexity of the cellular surface of astrocytes in culture. Further studies are needed to correlate these quantifiable changes in complexity with actual cytological structures.

Photophysics and photochemistry of hemoglobin interaction with ultrashort laser pulses

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Detection of fluorescence emission during the interaction of hemoglobin (Hb) with ultrashort laser pulses was observed in both *in vivo* and *in vitro* experiments[1,2], however, (Hb) is a non-fluorescent molecule at single-photon excitation. The mechanism of the two-photon fluorescence emission of specimens that contain (Hb) is unclear and still speculative. The latest results suggest that the interaction of ultrashort laser pulses with (Hb) is associated with the formation of (Hb) photoproduct [3]. Thus, two-photon fluorescence emission is probably related to the formed photoproduct, which chemical and photophysical properties are not completely understood so far. Here we present some revealed photophysical and photochemical properties of (Hb) photoproduct formation upon two-photon excitation. After irradiation at 730nm, using Ti: Sapphire laser (Coherent, Mira 900-F) with a pulse duration of 160fs, a fluorescent (Hb) photoproduct was formed. Square shape pattern of fluorescent (Hb) photoproduct (Figure 1.), created by raster-scanning using galvoscanning mirrors has been shown high stability and durability (for two-weeks). Moreover, it was possible to analyze formed (Hb) photoproducts by single-photon excitation microscopy, Uv-Vis, and Two-photon emission spectroscopy.

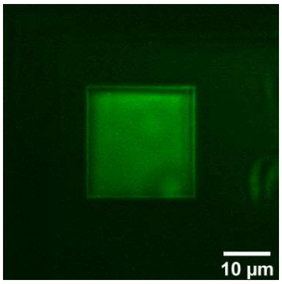

Figure 1. Scanning region of treated (Hb) thin layer with ultrashort laser pulses

There is a potential application of formed (Hb) photoproduct in studying Hemoglobin-related physiology and patophysiology [4, 5], as well as application out of biomedical field scope e.g., security and optical data storage.

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Optical measurement of neuronal Ca^{2+} and Na^{+} currents in the native system

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Abstract. In this talk I will present the basic principles of the optical measurement of native Ca^{2+} and Na^{+} currents from neuronal compartments in brain slices. The complex spatial morphology of neurons does not allow the measurement of ion currents using the conventional patch clamp technique, in particular the real ion currents underlying physiological signals. Ultrafast fluorescence imaging techniques, designed to measure intracellular Ca^{2+} and Na^{+} concentrations at sub-millisecond temporal resolution, can be exploited to provide faithful measurements of native currents at the site of origin. In addition, voltage imaging can provide an indirect measurement of the membrane potential necessary to correlate this parameter with the activation of ion channels. The optical analysis of neuronal ion currents is particularly important to understand the exact function of voltage-gated ion channels underlying physiological neuronal excitation. I will first present the work performed in my laboratory to achieve the optical measurement of Ca^{2+} currents [1-2], initially applied to hippocampal pyramidal neuron dendrites [3], and the more recent optical measurement of Na^{+} currents from the axon initial segment [4]. I will then analyse in detail the case of the cerebellar Purkinje neuron dendrites where the interaction of Ca^{2+} with fast mobile endogenous buffers prevents a straightforward extraction of Ca^{2+} current [5]. Yet, in this system, by combining the optical measurements with selective pharmacology and NEURON modelling, we precisely revealed the physiological kinetics of all ion channels underlying the dendritic excitation elicited by the climbing fibre synaptic potential [6]. In summary, optical measurements of Ca^{2+} and Na^{+} currents are the feasible approach to explore ion channels in their native environment.

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Morpho butterfly wings as imaging sensor

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Abstract. Detection of infrared radiation using the biological structures gathered increasing attention over the last decade [1,2], as the need for faster, more sensitive infrared imaging sensors grows ever stronger. Among the proposed techniques for the interrogation of the radiation-induced effects, digital holographic interferometry stands out as the simplest method for obtaining the spatio-temporal information about the response [3]. Using similar methods as described previously [3], with the radiation wavelengths of 405 nm, 450 nm, 660 nm and 980 nm, we prove that the natural structures found on the wing scales of the *Morpho Didius* butterfly can be used for the detection of radiation throughout the visible and near-infrared part of the optical spectrum. The effect itself is highly related to the temperature change of the wing scales, induced by the incoming radiation. Thus, it was of interest to investigate the effect of cooling of the wing's back surface, on the wing's temporal and spatial response. As expected, we obtained better frequency response at the expense of sensor sensitivity. The response of an uncooled wing to the 110 ms exposure with 980 nm, 2 mW laser radiation is shown in Figure 1. This result corresponds to the sensitivity of 51 rad/mJ which is about 11 times higher than our previously reported result [3]. Both the iridescent and non-iridescent side of the same wing showed similar sensing capabilities. The sensor response was shown to be repeatable over an extended period of time. The obtained results imply the promising potential of biomimetic *Morpho*-inspired radiation and imaging sensors in the broad spectral range.

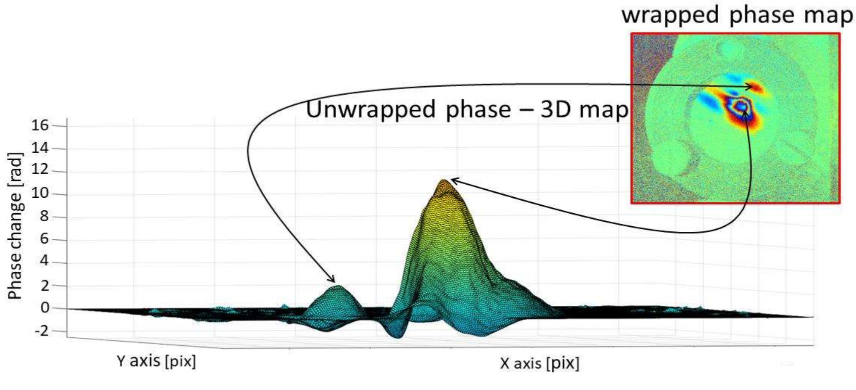

Figure 1. Holographic phase maps in 2D and 3D, illustrating the response of the *Morpho Didius* wing.

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Atomic line referenced Mach Zehnder Interferometer calibrators for reaching extreme precision radial velocities in Dopler spectroscopy

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Abstract. In order to detect Hot Jupiter or Super Earth a precise, accurate, controllable and predictable calibration system is required. Traditional Hollow Cathode Lamps (HCL) have their limitations in precision and unclear line broadening mechanisms and Laser Frequency Combs are prohibitively costly. All above criteria are met by use of Fiber Mach-Zehnder Interferometers that are absolutely referenced to the D2 line transition of Rubidium and Cesium atoms by means of Saturation Absorption Spectroscopy (SAS) or Dichroic Atomic vapor Laser Lock (DAVLL). The FMZI's are compact photonic devices that deliver a set of equidistant and homogeneous spectral features. In this work we present a stable, inexpensive wavelength calibration reference, fiber based white-light interferometer, for the use on future diffraction-limited Extreme Precision Radial Velocity (EPRV) astronomical spectrographs. The primary aim of using calibrator of this design is to obtain a dense, equidistant set of sinusoidal fringes for wavelength reference with spectral coverage between 690- 860 nm. Its basic setup consists of an unbalanced fiber Mach-Zehnder interferometer (FMZI) that creates an interference pattern in the white light due to superposition of phase delayed light, set by optical path-length difference (OPD) that is adjusted and kept stable by use of EOM phase modulator. To achieve extreme stability, the interferometer is actively locked to alkali atomic line transition (Cesium and Rubidium). The system operates in closed-loop by means of electro-optic phase modulator as the phase feedback component that keeps fringes stable. Stability is monitored through sensing of interferometric visibility function, on one of the interferometer exits, via photodiode with great amplification factor. We simulated stability measurements by superimposing simulated FMZI output reference spectrum with thorium-argon (Th-Ar) emission lines. By use of cross-correlation, absolute locking to hyperfine transition lines, and periodic referencing to Th-Ar lines we claim that stability of less than 5 m/s can be achieved over long baselines.

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Applications of astrophotonics: Diffraction limited single mode PCF Echelle spectrograph for Exoplanetology, Astroseismology and cv studies

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Abstract. In this work I will discuss the potential of using photonic technologies in the field of Astronomical spectroscopy and present prototype of high resolution (R>65,000) multi purpose spectrograph *Photonic* VELES (*Photonic* VEry Large resolution Echelle Spectrograph) suited for Extreme Precision Radial Velocities (EPRV) in exoplanetological studies, asteroseismological observations and characterization of stelar cataclysmic binary systems via Dopler Tomographic techniques all that coupled to small telescopes (<1m). In order to fulfill an ambitious task of detecting Juputer mass planet at 1 AU or less around a solar analogous star (so called Hot Jupiters) a suite of stringent requirements for instrument design have to be met: big spectral resolution, great spectral coverage and stabilisation of the instrument be it mechanical, pupil illumination and Point Spred Function (spatial, temporal and chromatic) stability. They are met by use of Photonic crystal *endlessly single mode* optical fibers that couple spectrograph to the telescope. Greatest hindrance to stability of classical echelle spectrographs is the PSF nonuniformity and the multitude of modes that propagate through the multimode fiber that transforms spatial and phase dependencies of input signal to inaccuracies in wavelength on CCD detector. PCF conducts only fundamental spatial LP01 mode that results in a spatiotemporal invariant Gausian beam profile through which modal noise is made nonexistent and SNR is increased by at lest 2 orders of magnitude. The requirement for high spectral resolution for Astroseimsmology (R>40,000) is maintained by use of LMA PCF fiber that present small exit aperture by which spectral resolution is order of magnitude larger that with conventional spectrograph of similar size and the optics of the spectrograph can be made order of magnitude smaller and less dependent on precise and costly aberration control and reduced volume implies that instrument is easy to temperature and pressure stabilize. Another requirement for cataclysmic star studies is high throughput which is done by use of classical MMF od few mode fiber along with anamorphic prism pair so that exit aperture is elongated to ellipse. The use and design of one such spectrograph will be presented in order to quantify the gains in resolution, SNR and spectral coverage.

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Single-photon holography

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Abstract.

Development of novel single-photon sources and single-photon detectors [1] supported by high speed acquisition electronic devices that can timestamp signals with picoseconds resolution opens broad range of possibilities in quantum optics as well as in holography.

We demonstrate that it is possible to record whole, amplitude and phase information of a real-world object by using single-photons, that are incompatible with classical wave theory. Also, by using precise arrival time of single photons, we show that we can record a holographic information under low flux conditions, when the hologram without timestamping is not detectable because of noise. The experimental scheme is implemented with single photon detectors and correlated photon pairs generated in a nonlinear crystal by the spontaneous parametric down conversion.

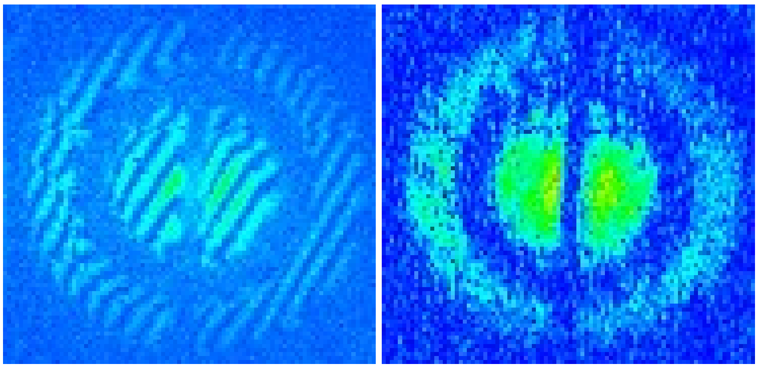

Figure 1. Digital hologram (left) recorded by using single photon detector and single photon states. Reconstruction of the digital hologram (right).

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Femtosecond laser spectroscopy for Exploration of Space: Introduction of new research group at German Aerospace Center

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Abstract. The Time-Domain Spectroscopy group (TLS - ZS) in the department of Terahertz and Laser Spectroscopy (TLS) has a long track record in instrumentation development and has in recent years pioneered terahertz time-domain set-ups demonstrating world-wide unique sensitivity levels [1,2]. It is currently working on developing compact laser-based spectroscopy techniques based on short-pulse lasers for future applications in e. g. robotic missions to extraterrestrial objects in our solar system. Scientific applications range from planetary research to nonlinear spectroscopy of novel quantum materials with applications in space instruments (e. g. topological insulators or Graphene[3]). The group is furthermore contributing its expertise in laser spectroscopy, optic design, detector development and qualification of spectroscopy components to different cross-sectoral projects within TLS.

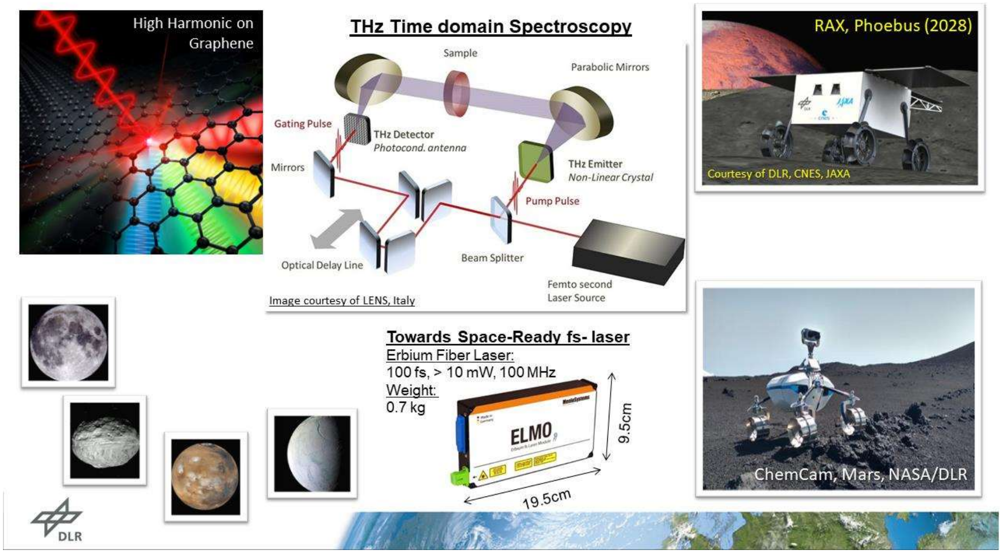

Figure 1. Towards new research enabled by space ready ultrafast lasers

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Bio-inspired materials with low angle dependence structural colors

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Abstract. The bright and iridescent structural colors that originate from the interaction of visible light with nanoscale structures are widely found in nature. Natural structural coloration is the inspiration for fabrication of artificial structural color materials, and their applications in widespread areas [1]. However, the angular dependence limits their use, especially in the field of sensors and displays [2]. In order to solve this problem, it is necessary to make non-iridescent color structures. We were inspired by the *Jordanita globularie* moth, whose wings have greenish-blue non-iridescent color [3]. In order to generate moth-like structures we have fabricated moth-mimetic structures in biopolymer via holography and non-solvent phase separation. Such a combination induces emergence of both ordered and disordered structures. We used a combination of surface and volume holographic gratings. Surface relief diffraction grating was formed by the interference of two equal power coherent beams, producing equivalent of the moth scale longitudinal ridges. Multilayer structures were fabricated as a volume (Bragg) reflection grating using a simple counter-propagating beams configuration. Multilayer consists of biopolymer Bragg layers, mutually separated and supported by nanopillars. In order to investigate the optical properties in the nano-structures of the moth wings and of the fabricated artificial wing reflectance spectra were measured from various viewing angles. Our photonic structure material displays bright and low angle dependence structural color, as *Jordanita globularie* moth.

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Search for ultralight bosonic ALP dark matter in form of topological defects: design, calibration, sensitivities of Belgrade GNOME station

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Abstract. In this work we present design, calibration of double resonant magnetometer and estimate on mass and interaction strength of hypothetical axionic or axion like dark matter namely their topological defects in form of domain walls or spatially distributed agglomerations (Q balls, axion stars, condensates etc.). Hypothetical axions or Axion Like Particles (ALP‘s) are form of ultralight bosonic matter that are postulated in order to solve strong CP problem and matter-antimatter imbalance in the Universe. Dark matter problem, exuberated by negative results of search for WIMP‘s, supersymmetric particles, core-cusp problem, missing satellites problem and others may be solved by type of ultralight matter into which axions fit. Also, by this type of matter GR and MOND can be reconciled and it has a many detectable signatures, one being in form of axionic field coupling to fermions that results in formation of pseudomagnetic fields during passage through topological defect. The GNOME experiment is designed as GPS referenced worldwide distributed network of quantum cross-correlated sensors that increases its sensitivity reach and excludes false positives by methodology similar to LIGO network. Belgrade GNOME station is built around double resonant RF optical cesium magnetometer in Mx configuration and is capable to function as scalar magnetometer with a sensitivity less than 100fT/√Hz. We will quantify various noise contributions, PSD, sensitivities, and stability over short and long baselines of the setup. Special accent will be given to experiment design and comparison between laser and lamp pumped magnetometer. Guidelines for future work and improvements shall also be mentioned.

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Real time fabrication of microlens arrays for security applications

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Microlenses and microlens arrays have found significant applications in integral imaging, illumination and, in particular, security [1-3]. Variability under different illumination and observation conditions with associated 3D effects make microlenses excellent security alternative to holograms. A new 100 $ US bill with 3D ribbon, filled with thousands of microlenses, is a newest example of practical application of microlenses for document security.

Here we present a method for fabrication of micron-sized security QR-codes (see Fig. 1) entirely made of positive and negative microlenses. Their focal lengths, size and focal images present a new security features, which can be intertwined with the QR code contents.

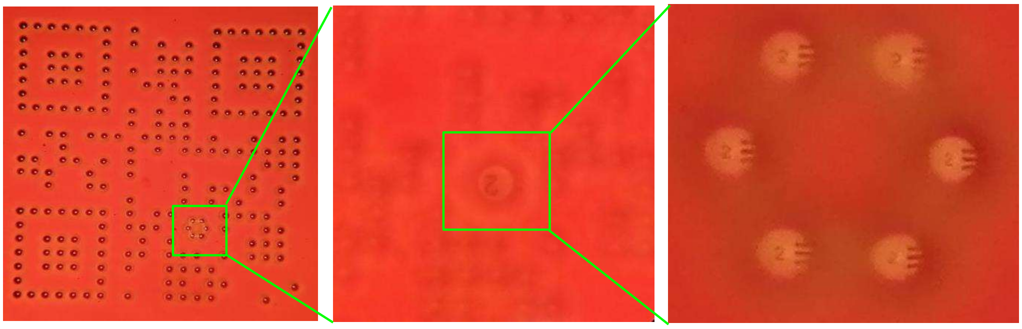

Figure 1. QR-code with positive and negative lenses

Security QR code is fabricated on a sensitized hydrogel using direct laser writing. Writing is based on local melting of hydrogel with consequtive formation of a lens like structure due to surface tension forces. Material is environmentally safe with low toxicity and microlens fabrication is fast - individual microlenses are produced in a fraction of a second - and requires no further processing. That is why security features can be fabricated in an individualized manner enabling uniquenes and complexity of security features.

By changing the laser beam profile, writing speed and pattern, complex aspherical lenses can be fabricated, thus adding to complexity of security features. Simplicity of the base material and associated laser processing technology opens way to many security applications.

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Rapid protyping of microlenses based on hydrogel materials

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Microlenses represent important optical components that have widespread applications in microscopy, biomedical engineering, security, etc. [1,4]. However, in most cases the production of usable microlenses is a complex technological task. Various techniques are used for microlens production such as micromolding, embossing, soft lithography [2,3,4]. Most of them don't have a high production rate, versatility, and modularity at the same time. Here we present a fast, simple, nontoxic and environmentally friendly technology for production of high-quality microlenses based on continuous wave laser processing of hydrogel materials. Direct laser writing at 488 nm is used to manufacture almost any type of microlenses within several milliseconds. Produced lenses are instantly usable without need for any further processing. We have been able to fabricate the different types of microlens: positive, negative, aspheric - and their arrays and combinations. Technology has a potential for rapid prototyping and serial production due to the modularity and versatility of the production process.

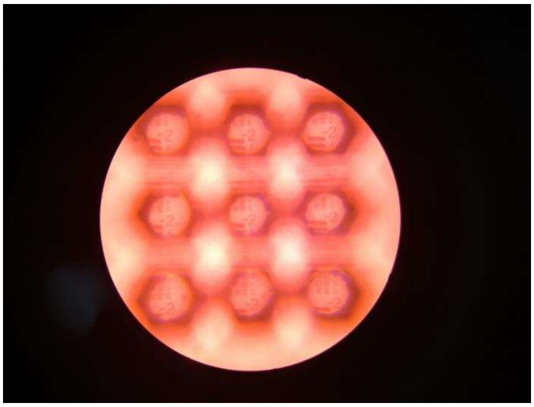

Figure 1. Positive 3x3 Microlens array

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Is solar going indoors?

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Abstract. Recent developments in the field of photovoltaics and their prospective role in the internet of things (IoT) applications indicate a clear need to leverage on their ability to operate indoors. Low-light harvesters are particularly interesting, as they can provide a driving source for low-power sensor nodes used in various IoT systems [1,2]. In this work, we propose a facile, low-cost solar cell fabrication approach towards efficient indoor light harvesters based on graphene/n-Si Schottky-junction. The cells exhibit the efficiency of 6% and only 0.2% in indoor and outdoor conditions, respectively; demonstrating a 30 times increase in efficiency indoors [3]. With Raman spectroscopy and thermovision we validate the operational stability of such devices over a period of 48 months and identify critical structural points responsible for performance degradation during the ageing process [4]. The high efficiency under indoor light is caused by large shunt (parallel) and serial resistances. As we used high quality c-Si which is very stable over many years and graphene that becomes more stable with time, we can conclude that the Ag contact degradation mostly impacts the cell performance. The cells are produced from liquid phase exfoliated graphene made by Langmuir-Schaefer assembly. In addition, cells were annealed (A cells) and then functionalized for 5 min by UV/ozone (AO cells). We found that AO cells exhibit a better performance than A cells even though they have a lower EQE. The main reason is the existence of a small Egap in AO. We assume that our cells are better in dark than light conditions because of intense recombination owing to the highly doped Si. Those cells have high concentrations of carriers leading to efficient photo conversion, but more light results in more carriers and a higher recombination rate, consequently reducing the efficiency of the cells. A good performance at low light intensities could significantly extend the usage of Si solar cells in indoor light conditions. Finally, the low cost solution production process of the graphene films will have an important impact on faster adoption of these devices.

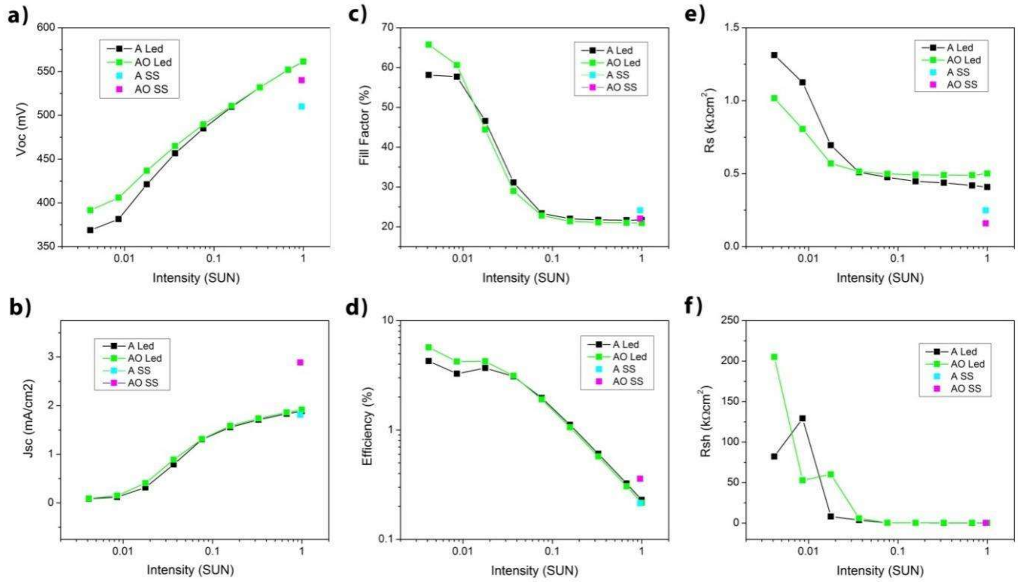

Figure 1. Solar cell parameters of pristine A and AO cells for different light intensities (indoor to outdoor) from LED (4200K, 0.004-1Sun) and Solar Simulator AM 1.5G (0.96Sun) light sources.

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Applications of optically pumped magnetometers

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Abstract. From discovery of lodestone (naturally magnetized magnetite) we became aware of and started to use magnets and magnetic fields. First application was navigation, a lodestone, suspended so it could turn, would orient itself in direction of Earth's magnetic field – first compass! Advances in science and technology led to development of wide variety of sensors detecting magnetic field [1]. What kind of sensor will be used for specific application is determined by sensitivity, size, accuracy, price, operational costs, operational temperature range, intensity, gradient and bandwidth of measured magnetic field… Optically pumped magnetometers (OPMs) hold their ground in between of highly sensitive, but expensive and cumbersome SQUIDs (Superconducting Quantum Interference Device) from one side and fluxgates, giant-magnetoresistive magnetometers (GMR), hall sensors, and many other being less expensive, but also less sensitive and less accurate. In other hand OPMs might be categorized by medium on which they operate where most notable are alkali vapor, noble gases, and nitrogen vacancy (NV) based magnetometers.

OPMs have broad range of applications in biomedical research, for example magnetoencephalography [2] and magnetocardiography [3]. They are used for mapping of geomagnetic fields in ore exploration, and archaeology [5]. In other hand OPMs are exploited in fundamental research for exotic interactions detection [6] and for measurement of neutron electrical dipole moment [7]. Nitrogen vacancies (NV) in diamond present miniature version of OPM that could be placed very close to a source of magnetic field thus overcoming its, presently, not very high sensitivity.

In the presentation several applications of OPMs will be discussed.

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Localized surface plasmon resonance (LSPR) for bioanalytical applications

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Abstract. The detection of (bio)molecules and cells represents a key part of todays diagnostics. Revealing the presence of e.g. viruses or bacterial pathogens is important in diagnostic routine but even more in pandemic situations. Often affinity sensors are utilized for detection, which rely on the highly specific binding of the target molecules by a so-called receptor or capture molecule. In the case of nucleic acids, which are utilized as biomarkers for viruses or bacterial pathogens, these capture molecules are single-stranded nucleic acids with complementary sequence, which will bind with high specificity to the target nucleic acid sequence. In order to increase the concentration of the target molecule – and so the detection limit of the method – amplification methods such as PCR (or isothermal variants e.g. LAMP) are employed. The specific, complementary binding of the capture DNA to the target can be sensed using gold nanostructures as sensors. Such structures show the effect of local surface plasmon resonance upon irradiation by visible light. Any change in refractive index on the nanostructure's surface will result in a change of resonance wavelength, this shift represents the sensor signal. By attachment of the capture molecules to the nanosensors, in the presence of complementary DNA molecules (target), these molecules will bind, so change the refractive index at the sensor#s surface, resulting in a resonance shift. This shift will point to the presence of target molecules [1].

For the case of DNA binding, both thermal or chemical means can reverse the binding, so that the reaction can be repeated again and again. By using a flow chamber, different analyte solutions containing none, the complementary or a noncomplementary DNA molecule can be chosen for incubation of the nanosensors, allowing for a high level of control. In order to multiplex the assay, gold nanostructures arrays were spotted on a glas substrate [2], and an imaging spectrometer has been developed in order to read out the spectral changes on all spots simultaneously [3], allowing thereby for a label-free, multiplexed molecular detection for diagnostical and bioanalytical applications [4].

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